UNIVERSITY OF CALIFORNIA
COLLEGE OF AGRICULTURE
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COMMERCIAL PRODUCTION OF DESSERT WINES

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INTRODUCTION

In Bulletin 639[4] the authors have considered the production of table wines—those which are ordinarily served with meals. The present publication includes the wines and related beverages derived from wines which are not usually used as table beverages. These wines are called "dessert" wines because of their predominant usage.[5] Their alcoholic content is increased by the addition of grape spirits during production and formerly therefore they were called "fortified" wines. The brandy added in their production serves essentially as a preservative of the natural grape sugars present in the wine. They usually retain some sugar so that they are popularly known as "sweet" wines in contradistinction to table wines, which are usually, but not always, free of sugar and are called "dry" wines. We prefer to utilize the nomenclature of "table" and "dessert" wine, since this corresponds with the usage of the wines and is free of the ambiguity inherent in the "dry" and "sweet" system of naming. The use of the term "fortified" is objectionable because of the implication that such wines resemble spirits. Vermouths, which are made from a wine base flavored with various herbs, are included in the discussion.

As stated previously in the bulletin on table wines, the production of

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[4] Amerine, M. A., and M. A. Joslyn. Commercial production of table wines. California Agr. Exp. Sta. Bul. 639:1–143. 1940.

[5] The use of the dual appellation "dessert and appetizer" for the before- and after-dinner wines is unnecessary, since "dessert" wine corresponds closely enough with usage. For previous use of the term "dessert wines," see:

Heide, C. von der, and F. Schmitthenner. Der Wein, 350 p. F. Viewveg und Sohn, Braunschweig, Germany. 1922.

Müller, K. Weinbau-Lexikon. 1,015 p. Paul Parey, Berlin, Germany. 1930.

The Italian term *vini di lusso* or roughly "luxury wines" is not satisfactory. But the *Likorweine,* liqueur wines, used by Grünhut is not a bad appellation. He also uses "dessert" wine, but in a somewhat broader sense than it is used here. (See: Grünhut, L. Die Begutachtung der Dessertweine. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel 26:498–524. 1913.) In France *vins de liqueur* is used for the high-alcohol sweet wines and *vins de liquoreux* for the medium-alcohol natural sweet wines, such as Sauternes. *Vino generoso* is the Spanish term used for wines containing added brandy.

dessert and appetizer wines introduces problems that are quite different from those presented by the wines of lower alcoholic content. Their production is very closely regulated and restricted by the United States Bureau of Internal Revenue, since they are subject to higher taxes than table wines. This is particularly true of the steps involving changes in alcoholic content and volume—the production of grape fortifying brandy, and the fortification of the wine—both of which are carried out under the supervision of the United States gauger. The period of fermentation is much shorter than for dry wines so that losses due to poor practice are minimized, and after fortification they are less subject to spoiling during aging and storage. This has led to the current opinion that less skill is required in making sound dessert wines than is necessary for dry table wines. The production of dessert wines of quality, however, requires great skill and the use of the finest varieties and best methods. These wines can, however, be subjected to pasteurization, oxidation, chilling, and other operations, carried out for the purpose of more rapidly mellowing or stabilizing them, with a less deleterious effect on flavor than is true of table wines. This has led to a considerable misuse of such practices in order to market these wines at a very early age, particularly in increasing the rancio flavor by overoxidation or caramelization. For proper aging, dessert wines, in general, must be stored for a longer period of time and often in smaller containers than table wines.

The commercial production of fortifying brandy and beverage brandy will be considered in a later publication.[6]

The present bulletin is based on investigations of the divisions of Fruit Products and Viticulture as well as on observations of sound commercial practice. The discussion is primarily related to production under commercial winery conditions. Those chiefly interested in practical directions for making dessert wines should turn directly to page 73.

ECONOMIC STATUS OF THE CALIFORNIA WINE INDUSTRY[7,8]

The commercial wine industry of California began in Los Angeles[9] in the middle of the nineteenth century and grew continuously until the passage of the Eighteenth Amendment restricted trade in wine.

[6] Joslyn, M. A., and M. A. Amerine. Commercial production of brandies. California Agr. Exp. Sta. Bul. 652. (In press.)

[7] Prepared in collaboration with S. W. Shear, Associate Agricultural Economist in the Experiment Station and Associate Agricultural Economist on the Giannini Foundation, who supplied the statistical data used.

[8] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 169.

[9] Leggett, H. B. The early history of the wine industry in California. Thesis for the degree of Master of Arts, University of California. 1939. (Typewritten.) Copy on file in the University of California Library, Berkeley.

According to Bioletti,[10] the production in 1857 amounted to but 150,000 gallons. By the early eighties it had reached a total of about 10,000,000 gallons. Table 1 shows that by 1890–1892 it averaged 17,367,000 gallons

TABLE 1

California Commercial* Wine Production and Grapes Crushed for Wine, Averages 1890–1939 and Annual 1933–1940

Years beginning July 1	Grapes crushed for wine†	Commercial wine production, net‡			
		Total	Table wines§	Dessert wines	
				Quantity	Per cent of total
	1	2	3	4	5
	tons	*thousand gallons*	*thousand gallons*	*thousand gallons*	*per cent*
Averages:					
1890–1892	126,247	17,367	15,210	2,157	12.4
1893–1898	158,622	19,630	13,826	5,804	29.6
1899–1903	248,770	28,497	17,188	11,309	39.7
1904–1908	311,457	35,204	20,968	14,236	40.4
1909–1913	397,100	43,595	24,434	19,161	44.0
1914–1918	309,410	36,120	22,463	13,657	37.8
1933–1934	442,500	36,342	15,352	20,990	57.8
1935–1939	690,600	63,908	16,528	47,380	74.1
Annual:					
1933	386,000	35,679	19,627	16,052	45.0
1934	499,000	37,005	11,077	25,928	70.1
1935	846,000	65,690	11,677	54,013	82.2
1936	459,000	46,679	11,979	34,700	74.3
1937	853,000	85,351	28,049	57,302	67.1
1938	617,000	50,342	14,761	35,581	70.7
1939	678,000	71,478	16,174	55,304	77.4
1940¶	898,000	103,000	23,000	80,000	77.7

* In addition to commercial production of wine, quantities of homemade table wine produced from California grapes averaged 33,840,000 gallons in 1933 and 1934 and 32,889,000 gallons in 1935–1939. (The United States standard gallon, or wine gallon, is used in all tables.)

† Excludes grapes crushed for the production of commercial beverage brandy.

‡ Data are for net production, which is determined after allowances are made for normal shrinkage losses, distillation, diversion to by-product use, and other purposes.

§ Data on champagne and other sparkling wines included 1890–1918 but excluded 1933–1940.

¶ Rough preliminary 1940 estimates subject to considerable revision.

Sources of data:

Compiled by S. W. Shear, Univ. California Giannini Foundation of Agricultural Economics.

Averages 1890–1918 data from: Shear, S. W., and Gerald G. Pearce. Supply and price trends in California wine-grape industry, Part 2. Univ. California Giannini Foundation. Mimeo. Rept. **34**. tables 9, 35, and 42. 1934.

Col. 1: Based on data in table 42, cols. 4 and 5, and table 35, col. 6.

Cols. 2–4: Data in table 9, cols. 2, 5, and 8.

1933–1940 data from: Shear, S. W. Deciduous fruit statistics as of January, 1941. Univ. California Giannini Foundation. Mimeo. Rept. **76**. Grape tables 4, 15, and 16.

Col. 1: Data from grape table 4, col. 5, minus data for 1933–1937 in grape table 16, col. 8, and minus data on beverage brandy production for 1938–1940 from the Wine Institute as of March 19, 1941.

Cols. 2–4: Grape table 15, cols. 4–6.

[10] Bioletti, F. T. The wine-making industry of California. International Institute of Agriculture, Agricultural Intelligence and Plant Diseases Monthly Bul. 6 (2):1–13. 1915.

a year, of which about one eighth consisted of dessert wines.[11] The industry grew so rapidly during the next two decades that by 1909–1913 it had reached a pre-Prohibition peak of production of 43,595,000 gallons a year, constituting about 85 per cent of national production. Dessert wines had increased in production so much more rapidly than had table wines that they had risen to about 44 per cent of the total, or slightly over 19,000,000 gallons. Nearly half of this output of dessert wines consisted of the port type, according to the official classification of the United States Commissioner of Internal Revenue, nearly one third of sherry, and the balance mostly muscatel and Angelica, together with small amounts of Malaga, Madeira, and Tokay.

During 1909–1913, consumption of commercial wine in the United States averaged about 50,000,000 gallons, or 0.52 gallon per capita (see table 2). Foreign wine constituted 7,392,000 gallons, or about 15 per cent of this total, and California wines about 80 per cent. Most of the wine not originating in California was dry table wine, so that only about 39 per cent of the national consumption consisted of dessert wines. Of the average per-capita consumption of commercial wine in the United States during that period, about 0.32 gallon consisted of table wines and 0.20 gallon of dessert wines.

Almost no homemade wine was produced and consumed in the United States before Prohibition. Prohibition, however, stimulated the production of homemade wine to such an extent that per-capita consumption of wine actually reached its peak during Prohibition, for several years during that period amounting to more than the 0.77 gallon average consumption of all wines during the years since Repeal—1933–1939. Most of the homemade wine consumed during Prohibition was presumably natural table wine, containing about 13 per cent alcohol, some of which was probably obtained from added sugar. The estimates by Shear given in table 2 show that even since Repeal a considerable amount of this untaxed wine has been produced. Annual consumption of such wines made from California grapes probably has averaged close to 1 quart per capita since Repeal, with relatively little deviation from year to year. Consumption of tax-paid commercial wine has, however, increased substantially since Repeal, which has resulted in a decrease in the proportion of homemade wine from 47 per cent of total wine consumption in 1934 to 29 per cent in 1939. Roughly 60 per cent of the consumption of all dry table wines in 1939 still appears to have consisted of untaxed homemade wine made from California grapes.

The wine industry has become much more important in the United

[11] See also: Shear, S. W., and G. G. Pearce. Supply and price trends in the California wine-grape industry. Univ. California Giannini Foundation. Mimeo. Rept. 34. table 9. 1934.

TABLE 2

UNITED STATES APPARENT CONSUMPTION OF DESSERT AND TABLE WINES,* YEARS BEGINNING JULY 1; AVERAGES 1909–1913 AND 1935–1939, AND ANNUAL 1933–1940

Year beginning July 1	Total		Dessert, over 14 per cent alcohol, commercial	Table, not over 14 per cent alcohol		
	Commercial and homemade	Commercial		Total	Commercial	Homemade
			Total consumption			
	thousand gallons	*thousand gallons*	*thousand gallons*	*thousand gallons*	*thousand gallons*	*thousand gallons*
Averages:						
1909–1913	49,445	49,445	19,198	30,247	30,247	0
1935–1939	100,160	67,271	44,606	55,554	22,665	32,889
Annual:						
1933	52,146	17,526	10,973	41,173	6,553	34,620
1934	70,916	37,856	24,491	46,425	13,365	33,060
1935	86,027	50,012	32,958	53,069	17,054	36,015
1936	95,338	65,503	42,775	52,563	22,728	29,835
1937	98,895	64,230	41,350	57,545	22,880	34,665
1938	99,753	70,533	46,493	53.260	24,040	29,220
1939	120,785	86,075	59,453	61,332	26,622	34,710
1940†	125,511	90,741	63,045	62,466	27,696	34,770
			Per-capita consumption			
	gallons	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*
Averages:						
1909–1913	0.52	0.52	0.20	0.32	0.32	0.00
1935–1939	.77	.52	.34	.43	.18	.25
Annual:						
1933	.41	.14	.09	.32	.05	.27
1934	.56	.30	19	.37	.11	.26
1935	.67	.39	.26	.41	.13	.28
1936	.74	.51	.33	.41	.18	.23
1937	.76	.49	.32	.44	.17	.27
1938	.76	.54	.36	.40	.18	.22
1939	.92	.65	.45	.47	.20	.27
1940†	0.95	0.69	0.48	0.47	0.21	0.26
			Percentage of total consumption			
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Averages:						
1909–1913	100.0	100.0	38.8	61.2	61.2	0
1935–1939	100.0	67.2	44.6	55.4	22.6	32.8
Annual:						
1933	100.0	33.6	21.0	79.0	12.6	66.4
1934	100.0	53.4	34.5	65.5	18.9	46.6
1935	100.0	58.1	38.3	61.7	19.8	41.9
1936	100.0	68.7	44.9	55.1	23.8	31.3
1937	100.0	64.9	41.8	58.2	23.1	35.1
1938	100.0	70.7	46.6	53.4	24.1	29.3
1939	100.0	71.3	49.2	50.8	22.1	28.7
1940†	100.0	72.3	50.2	49.8	22.1	27.7

* Includes imports which averaged 3,221,000 gallons a year during 1935–1939 or 3.2 per cent of consumption, about half dry and half sweet.

† Preliminary estimates.

Sources of data:

Compiled by S. W. Shear, Univ. California Giannini Foundation of Agricultural Economics.

Average 1909–1913 data from: Shear, S. W., and G. G. Pearce. Supply and price trends in the California wine-grape industry, Part 2. Univ. California Giannini Foundation. Mimeo. Rept. 34. table 7. 1934.

1933–1940 data from: Shear, S. W. Deciduous fruit statistics as of January, 1941. Univ. California Giannini Foundation Mimeo. Rept. 76:72. Grape table 14. 1941.

States since Repeal than in pre-Prohibition days. Table 1 shows that California production of commercial wines alone averaged nearly 64,000,000 gallons during 1935–1939, or nearly 50 per cent greater than during 1909–1913. Table 2 shows that United States consumption of all wine rose rapidly after Repeal from 0.56 gallon per capita in 1934 to 0.92 in 1939, averaging 0.77 gallon per capita during 1935–1939. Only 3.2 per cent of the total was imported during 1935–1939. California consumed an average of about 23 per cent of the total national consumption during 1935–1939, or 3.58 gallons per capita.

As in pre-Prohibition days, the consumption of dessert wines increased rapidly, rising from 0.19 gallon in 1934 to 0.45 gallon in 1939, and averaging 0.34 gallon per capita during 1935–1939. About 66 per cent of United States consumption of commercial wines consisted of dessert wines during 1935–1939, as compared with 39 per cent during 1909–1913. But when estimates of noncommercial, homemade, or basement wine are included in the total, only 45 per cent of all wine consumed in the United States appears to have been dessert wine during 1935–1939. There are no comprehensive statistics on the production of the different kinds of dessert wine since Repeal, such as were officially reported by the Commissioner of Internal Revenue before Prohibition. Vintners estimate, however, that port and sherry account for the greater proportion of the production, with muscatel, Angelica, Tokay, Madeira, and Marsala following in the order of importance. The latter two types are of very restricted importance.

The geographical distribution of the California acreage of grapes for wine making is shown in table 3, while table 4 shows wine production for 1940 by chief counties and districts. These data show that the wine industry is widely distributed in the state. Although wines of all types are produced in nearly every district, production of dessert wines is very largely concentrated in the interior valleys, from Sacramento County south to Kern County, with the largest centers in Fresno and Lodi. Yields per acre are higher and cost of producing grapes lower in these great interior valleys than in the coastal valleys of the state, which very largely produce table wines. Some dessert wines are produced in the coast counties, however, largely from grapes shipped in from the interior valleys, and in part from grapes grown there. A limited but important production of dessert wines is centered in southern California. Muscatel wine is made largely in the lower San Joaquin Valley, where the acreage is largest, although large amounts of muscat grapes are delivered to wineries in other districts.

There has been a tendency in recent years to divert more grapes of raisin and table varieties into wine and brandy than in pre-Prohibition

days. The fact that both raisin and table grapes have been in greater abundance and usually cheaper than before Prohibition has greatly increased their use by vintners. Moreover, winery demand for muscat

TABLE 3

California Total Acreage* of Grapes by Classes and Wine Grapes by Varieties and by Districts,† 1936, and State Total, 1939

Variety and class	1939	1936					
	State total	State total‡	North coast	Southern California	Sacramento Valley	Central Valley	San Joaquin Valley
	1	*2*	*3*	*4*	*5*	*6*	*7*
	acres	*acres*	*acres*	*acres*	*acres*	*acres*	*acres*
Totals:							
All varieties	514,414	497,021	63,517	43,914	8,853	84,068	293,991
Raisin varieties	254,401	243,500	555	10,431	2,865	7,268	222,247
Table varieties	85,019	81,424	1,123	4,555	849	28,300	46,442
Wine varieties	174,994	172,097	61,839	28,928	5,139	48,500	25,302
Red wine, total	159,445	158,182	54,389	26,512	5,000	47,156	22,858
Zinfandel	53,307	53,343	19,944	7,706	1,554	18,335	4,779
Carignane	30,854	30,729	11,381	2,387	456	12,123	4,281
Alicante Bouschet	29,321	30,240	4,457	3,470	849	11,919	9,434
Mission	10,971	10,164	1,009	4,352	576	2,645	910
Mataro	8,143	7,977	2,582	3,506	1,264	382	216
Petite Sirah	7,819	7,508	5,818	93	101	892	599
Grenache	3,269	2,980	837	1,222	49	150	722
Others	15,761	15,241	8,361	3,776	151	710	1,917
White wine, total	15,549	13,915	7,450	2,416	139	1,344	2,444
Palomino	3,996	3,020	1,405	599	9	567	440
Burger	2,981	2,639	914	1,070	8	404	207
Sauvignon vert	1,603	1,545	1,413	61	14	26	27
Sylvaner	506	507	459	15	2	1	29
Others	6,463	6,204	3,259	671	106	346	1,741

* Includes total bearing and nonbearing acreage.

† The districts (after Bioletti) include the following counties: North Coast—Lake, Marin, Solano, Mendocino, Napa, Sonoma, Alameda, Contra Costa, San Benito, Santa Clara, San Luis Obispo, and Santa Cruz; southern California—Riverside, San Bernardino, Imperial, Los Angeles, Orange, San Diego, and Ventura; Sacramento Valley—Placer, Sutter, Butte, Colusa, Glenn, Tehama, Yolo, and Yuba; Central Valley—Sacramento, San Joaquin, and Stanislaus; San Joaquin Valley—Fresno, Kern, Kings, Madera, Merced, and Tulare.

‡ Includes sum of data in cols. 3–7 plus data in other counties not included in the district totals given.

Sources of data:

Compiled by S. W. Shear, Univ. California Giannini Foundation of Agricultural Economics, based on data from:

Blair, R. E., W. R. Schreiber, and C. N. Guellow. California fruit and nut acreage survey 1936. U. S. Agricultural Adjustment Administration Statistical Publication 1: 11, 49, and 57–71. January, 1938.

Blair R. E., and H. C. Phillips. Acreage estimates of California fruit and nut crops as of 1939. p. 24, 25. California Coöperative Crop Reporting Service, Sacramento, Calif. 1940.

grapes has rapidly increased because of the greater popularity of muscatel wine. Increased use of neutral wine as an alcoholic vehicle for pharmaceutical and similar beverage industries has also increased vintners' demand for the ordinary wines produced from raisin- and table-

TABLE 4

California Commercial Grape Crush, Gross Production of Wine, and Storage Capacity by Districts and Counties, 1940

District and county	Grapes crushed* for wine and brandy	Wine production, gross†				Storage capacity‡
		Total	Dessert	Table		
				Red	White	
	1	2	3	4	5	6
	tons	*thousand gallons*	*thousand gallons*	*thousand gallons*	*thousand gallons*	*thousand gallons*
State total	995,981	105,690	78,320	20,362	7,008	196,235
North coast, total	138,986	22,004	3,424	15,047	3,533	56,556
North of San Francisco Bay:	106,532	17,431	1,860	13,039	2,532	41,970
Mendocino	5,725	963	122	733	108	2,346
Napa	32,483	5,395	328	3,999	1,068	13,475
Sonoma	65,520	10,727	1,212	8,229	1,286	25,106
Other§	2,804	346	198	78	70	1,043
South of San Francisco Bay:	32,454	4,573	1,564	2,008	1,001	14,586
Alameda	8,516	1,182	413	330	439	3,841
Contra Costa	733	129	0	87	42	524
San Francisco	44	7	0	7	0	3.453
Santa Clara	22,467	3,146	1,150	1,511	485	6,393
Other§	694	109	1	73	35	375
Southern California:	76,841	8,740	6,603	1,433	704	20,035
Los Angeles	12,037	1,496	1,025	270	201	4,230
San Bernardino	63,147	7,014	5,517	1,023	474	14,950
San Diego	968	129	46	65	18	503
Other§	689	101	15	75	11	352
Sacramento Valley§	2,743	362	145	192	25	613
Central Valley, total	288,195	29,780	25,112	2,938	1,730	48,964
Sacramento	42,655	4,239	4,055	125	59	6,829
San Joaquin	204,276	21,301	18,546	1,335	1,420	34,405
Stanislaus	41,264	4,240	2,511	1,478	251	7,730
San Joaquin Valley:	489,216	44,804	43,036	752	1,016	70,067
Fresno	281,323	24,607	23,893	255	459	42,922
Kern	30,827	2,753	2,735	14	4	3,389
Kings	12,002	1,752	1,697	0	55	1,018
Tulare	132,276	12,928	12,283	247	398	16,735
Other§	32,788	2,764	2,428	236	100	6,003

* Data are for July 1–December 31, 1940. Small quantities of raisins and other fruits not included.

† Gross wine production as of December 31, 1940, without allowances for subsequent losses, removals for distillation, increases resulting from amelioration and fortification, etc.

‡ Storage capacity as of December 31, 1940. Includes fermenters usable for storage.

§ District data designated as "other" may include small amounts outside of the district.

"Other" includes the following counties by districts: North of San Francisco Bay—Humboldt, Lake, Marin and Solano; South of San Francisco Bay—Monterey, San Benito, San Mateo, and Santa Cruz; southern California—Riverside, Santa Barbara, and Ventura; San Joaquin Valley—Madera and San Luis Obispo; Sacramento Valley, total, includes Amador, Butte, Calaveras, Merced, Nevada, Yolo, Yuba, and Placer.

Source of data:
Compiled by S. W. Shear. Univ. California Giannini Foundation of Agricultural Economics, from: Wine Institute. Fifth wine industry statistical survey. Confidential Bul. **102**: 18, 19. March 19, 1941. (Mimeo.)

grape varieties, such as Thompson Seedless (Sultanina) and Emperor. These grapes are considered useful, however, in the production of neutral grape spirits for fortifying dessert and appetizer wines and for sale as a fruit spirit.

Since Repeal almost no California grapes have been wasted, the wine and brandy industry utilizing all that have not been shipped fresh or dried. Of the average annual quantity of California grapes harvested during 1935–1939, about 44 per cent was used for commercial and noncommercial wine and brandy, or approximately 986,000 tons. Of this total, about 576,000 tons, or 58 per cent, consisted of wine-grape varieties, about 227,000 tons, or 23 per cent, of raisin varieties, and 183,000 tons, or 19 per cent, of table varieties. More California grapes were used for wine and brandy making in 1940 than ever before, preliminary estimates indicating that a total of about 1,186,000 tons, or 54 per cent of the 1940 crop, was used by vintners. About 51 per cent of this total consisted of wine varieties, 33 per cent of raisin, and 16 per cent of table varieties.

The increasing supply of wine made from raisin and table grapes and the lower quality of much of this wine have greatly increased the marketing problems of the wine industry. The need of increasing the demand and consumption for such wine is accentuated by the unusually large quantities of raisin and table grapes diverted into wine and brandy making from the 1940 crop as a result of the loss of much of the market for California raisins and table grapes, particularly the export market for raisins. Preliminary estimates indicate that about 103,000,000 gallons of commercial wine were produced in California in 1940, or about 31,500,000 gallons more than in 1939. Imports of foreign wines into the United States averaged 3,221,000 gallons a year during 1935–1939. The marked decrease in imports resulting from the European war in 1940 and 1941 caused some increase in the demand for California wines. Export markets for wine were investigated in this period, and some increase in the small amounts formerly exported will probably occur if the war continues to restrict exports from the European countries.

Vermouth, made by blending basic fortified wines with characteristic flavoring materials, is being made in the United States in increasing quantity, as shown in table 5. Liberalization of restrictions governing its manufacture, decrease in taxation, and reduction in imports as a result of the European war of 1939 have accounted for the rapidly growing vermouth industry. California wines are used, almost exclusively, as bases for United States vermouth; the flavoring materials, however, are largely imported.

TYPES OF DESSERT WINES AND THEIR COMPOSITION[12]

COMPOSITION

The chemical composition of dessert wines differs in several important respects from that of table wines. These differences are due to several factors, of which the most important are those resulting from differ-

TABLE 5

UNITED STATES PRODUCTION AND CONSUMPTION OF VERMOUTH, YEARS BEGINNING JULY 1, 1934–1939

Year beginning July 1	Production				United States consumption			
	United States			California * †	Total	Foreign	Domestic	
	Total	At wineries†	At rectifying plants‡				Quantity	Per cent of total
	1	2	3	4	5	6	7	8
	gallons	gallons	gallons	gallons	gallons	gallons	gallons	per cent
1934......	138,658	0	138,658	25,911	1,070,642	931,984	138,658	13.0
1935......	180,527	0	180,527	40,658	1,125,748	945,221	180,527	16.0
1936......	243,444	164,747	78,697	71,568	1,463,013	1,301,604	161,409	11.0
1937......	220,192	201,481	18,711	105,536	1,325,412	1,153,494	171,918	13.0
1938......	216,984	206,184	10,800	78,249	1,436,716	1,238,628	198,088	13.8
1939......	488,785	479,074	9,711	156,181	2,185,461	1,781,505	403,956	18.5

* California production at rectifying plants excluded for 1937–1939 because data not available. Vermouth produced at California rectifying plants in wine gallons was: 1934, 25,911; 1935, 40,658; and 1936, 36,647; and was probably very small since 1936 judging by United States production in column 3.

† Production of vermouth in wineries was first permitted June 26, 1936, under the Liquor Tax Administration Act.

‡ Vermouth produced at rectifying plants officially reported in proof gallons, and here multiplied by 2.77777 to convert to approximate wine gallons.

Source of data:

Compiled by S. W. Shear, Univ. California Giannini Foundation of Agricultural Economics.

Col. 1: Sum of cols. 2 and 3.

Col. 2: From: U. S. Bureau of Internal Revenue, Alcohol Tax Unit. Statistics on wine. Annual mimeographed reports.

Col. 3: 1934–1936 from: United States Tariff Commission. Grapes, raisins and wines. U. S. Tariff Comm. Rept. 2d ser. **134**: 242.

1937–1939 from: U. S. Bureau of Internal Revenue, Alcohol Tax Unit. Statistics on distilled spirits and rectified spirits and wines. Annual mimeographed reports.

Col. 4: Same source as cols. 2 and 3.

Col. 5: Sum of cols. 6 and 7.

Col. 6: July–Dec., 1934, estimated. Jan., 1935–Dec., 1936, from: Wine Institute. Third wine industry statistical survey. Bul. **86**: 33, 34. July 19, 1939.

Jan., 1937–June, 1940, from: U. S. Bureau Foreign and Domestic Commerce, Imports of distilled liquors, wines, cordials, and malt liquors. Mimeographed Monthly Release **3063**.

Col. 7: Sum of United States tax-paid withdrawals of vermouth from wineries, as reported by: U. S. Bureau of Internal Revenue, Alcohol Tax Unit. Statistics on wine. Annual mimeographed reports. Plus production in col. 3. Tax-paid withdrawals of vermouth made at rectifying plants are not available in official reports.

ences in production and handling; namely, (*a*) the addition of fortifying brandy to dessert wines, with the resulting dilution of the fermentation products as well as other constituents and secondary effects of the higher alcohol content, for example, precipitation of tartrates and extraction of

[12] General references on this subject in addition to those given in specific footnotes in this section are listed on p. 169–71.

substances from the wood; (*b*) the restricted period of fermentation of dessert wines and the resulting decrease in fermentation products and in extraction of certain substances from the skins; (*c*) the heating of dessert wines or the addition of heated musts or wines to them; (*d*) the different chemical composition of the raw material; (*e*) the increased period of aging accorded some dessert wines—usually in moderately warm cellars. The influence of each of these factors on the composition of dessert wines will be more apparent in the discussion of the individual constitutents which follows.

Acids.—The varieties of grapes used for dessert wines are naturally lower in total acid content and higher in pH than those used for the table wines, and the sugar-acid ratio is greatly increased.[13] Since the grapes intended for dessert wines are commonly grown in the warmer districts of California, their acidity is still further restricted. The dilution effect of fortification is also an important factor in the reduced acidity of the finished wine. Finally, the higher alcohol content after fortification favors the precipitation of tartrates. The amounts of succinic acid present in dessert wines is also less than that of table wines owing to the reduced period of fermentation. Acid tartrate, but usually not free tartaric acid, is the chief acid material present. Small amounts of malic acid and acid malates are also found. Citric acid is reported in sweet wines in amounts as low as those commonly found in table wines, or lower.[14]

California dessert wines are generally lower in total acid than comparable European types. The reduced acidity is so exaggerated in some musts as to make them difficult to ferment cleanly as well as to make the resulting wines taste too flat. These low acidities are partly due to the very large amounts of raisin and table grapes used for dessert wines in California—varieties which, in general, have very low acidities; partly to the delayed harvesting practices current in California; and partly to the excessive crops.

A range of 0.30 to 0.65 per cent total acidity for finished dessert wines is sufficiently broad and a smaller range of 0.40 to 0.65 may be desirable. At present, acidities as low as 0.20 per cent are found in some California dessert wines. (See tables 8–12.)

Acetic acid is found in only small amounts in dessert wines unless spoilage starts in the must in the early stages of fermentation, as some-

[13] Amerine, M. A., and A. J. Winkler. Maturity studies with California grapes. I. The Balling-acid ratio of wine grapes. American Society for Horticultural Science Proceedings 38:379–87. 1941.

[14] Heiduschka, A., and C. Pyriki. Beitrag zur Kenntnis des Citronensäuregehaltes von Traubenmosten und Traubenweinen. Zeitschrift für Untersuchung der Lebensmittel 54:466–73. 1927.

times happens.[15] Only an occasional post-Prohibition California dessert wine, however, shows a volatile acid content which is above the California limits of 0.110 per cent (0.120 per cent outside of California). (See tables 6 and 8–12.)

The pH values of California dessert wines are much higher than those of California table wines. They range from about 3.5 to 4.2, as compared with 2.9 to about 3.8 for table wines. These high pH values result from the reduced acidity and restricted buffer capacity of dessert-wine musts as well as from the influence of their increased alcohol and sugar contents.

TABLE 6

LIMITS FOR CERTAIN CONSTITUENTS IN DESSERT WINES SET BY THE CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH AND BY THE FEDERAL REGULATIONS

Authority	Alcohol,* range	Maximum volatile acid as acetic	Minimum sugar
	per cent	*grams per 100 cc*	*Balling degree*
California	19.5–21.0	0.110	5.5†
Federal	18.0–21.0‡	0.120§	—

* Sacramental wines are exempted. The general practice of the government authorities is to permit a 0.5 per cent tolerance.

† Except for sherry which now has a maximum of 4 per cent reducing sugar. At a recent meeting (July, 1941), while this bulletin was in press, the Standardization Committee of the Wine Institute met and proposed that the reducing sugar content of wines labeled "California dry sherry" be 0 to 2½ per cent, those labeled "California sherry," 0 to 4 per cent, and those labeled "California sweet sherry," 4 to 7 per cent. The minimum Balling degree for California Tokay was set at 3.5°. A minimum total acidity for all dessert wines of 0.30 per cent was proposed.

‡ Vermouth has a minimum limit of 15 per cent; sherry has a minimum of 17 per cent.

§ Exclusive of sulfur dioxide.

Alcohols.—The alcohol content of dessert wines may vary from 18.5 to 21.0 per cent according to federal law, and in California the limits are from 19.5 to 21.0. These limits are closer than those found in comparable European types. The enforcement of the 19.5 minimum limit also forces the fortification of some dessert wines (uncooked sherries, for example) to an undesirably high level (21.0 per cent). At a lower original percentage of alcohol, the wines would become palatable sooner and the dilution of the aroma and extract by the fortification would be reduced. Reduction of the minimum limit to about 17.5 per cent would therefore be of considerable value in improving quality, but might encourage dilution of dessert with table wines.

Ethyl alcohol is the chief alcohol present, but measurable quantities of other alcohols are also found, mainly methyl, amyl, isoamyl, *n*-butyl, isobutyl, *n*-propyl, hexyl, and heptyl. Since most of the alcohols in dessert wines—with the possible exception of some Spanish sherries—are derived from the fortifying brandy, they will be discussed in Bulletin 652

[15] Cruess, W. V. "Volatile" in Muscatel. The Wine Review 4 (5):18–20. 1937.

(cited in footnote 6, p. 4). The total amount of the higher alcohols present does not exceed 1 per cent of the total alcohol content. The methyl alcohol content is also low. Methyl alcohol may, however, be expected in dessert wines made with fortifying brandy high in this substance.

Mannite, a polyhydric alcohol, is formed in wines as a result of bacterial action. In European wines it commonly occurs as a result of infection during fermentation, but under California conditions it is formed chiefly as a result of infection during storage (see p. 144). It is not usually harmful to the taste of dessert wines but does indicate bacterial contamination.

During aging, losses in alcohol may occur by evaporation, directly or during routine winery operations, or by esterification. In Spain, under certain conditions, increases in alcohol during aging, amounting to several per cent, are reported.[16] This is apparently due to differential loss of water through the wood during aging. Such changes are rare in California, where very large containers are used more commonly. Usually small losses are reported, particularly during the baking of sherry, during pasteurization, filtration, centrifuging, and racking.

Sugars.—The two chief sugars present in grapes are dextrose and levulose. During ripening of the grapes, the levulose-dextrose ratio of the grapes increases to about 1. After full maturity the ratio may slightly exceed 1. Since dessert wines are made from fully ripe grapes, ratios of at least 1 are common. According to Hopkins and Roberts,[17] the dextrose is fermented more rapidly than levulose so that the levulose-dextrose ratio should increase during the early stages of fermentation. Wines whose fermentation has been stopped by the addition of alcohol should then show a ratio considerably above 1, and Kniphorst and Kruisheer[18] have found this to be the case in genuine European port, Tokay, and Sauternes wines.[19] Both fortified musts and wines which have been fermented nearly dry and then sweetened with concentrate showed

[16] Castella, F. de. Sherry. Victoria Department of Agriculture Journal 24:690–98. 1926.

González Gordon, M. Mª. Jerez-Xeres-"Scheris." 405 p. Imprenta A. Padura, Jerez de la Frontera, Spain. 1935.

Anonymous. The Lancet Analytical Commission on sherry: its production, composition, and character. Lancet 1898 (II) :1134–40. 1898.

[17] Hopkins, R. H., and R. H. Roberts. Kinetics of alcoholic fermentation of sugars by brewer's yeast. II. The relative rates of fermentation of glucose and fructose. Biochemical Journal 29:931–36. 1935.

[18] Kniphorst, L. C. E., and C. I. Kruisheer. Die Bestimmung von 2–3 Butylenglykol, Acetylmethylcarbinol und Diacetyl in Wein und anderen Gärungsprodukten. II. Anwendung des Verfahrens auf die Untersuchungen einiger Weintypen. Zeitschrift für Untersuchungen der Lebensmittel 74:477–85. 1937.

[19] Harden reports that the Sauternes strain of wine yeast ferments levulose more rapidly than dextrose. (Harden, Arthur. Alcoholic fermentation. 4th ed. 243 p.; see especially p. 192–94. Longmans, Green and Co., London. 1932.)

the expected ratio of about 1. These included certain wines of Malaga and Tarragon, Spain, which are frequently prepared by the use of reduced musts. Similar results are reported by Szabó and Rakcsányi,[20] who found that when wine was made from grapes of a very high initial sugar concentration, the levulose-dextrose ratio was near 1 after fermentation. They also found the ratio to be about 1 when concentrate was added. But they found two to six times as much levulose as dextrose in natural sweet wines of low sugar content. Similar results have been obtained in the fermentation of a concentrate with *Zygosaccharomyces* sp. by Parisi, Sacchetti, and Bruini.[21] These workers also report that in very sweet musts the levulose fermented more rapidly than dextrose in the early stages of fermentation.

Other changes in composition due to differences in the rate of fermentation of levulose and dextrose cause the originally dextrorotatory must to become levorotatory during the early stages of fermentation. Since dextrose is less sweet to the taste than levulose (in relation to sucrose as 100, the sweetness of dextrose is about 74 and that of levulose is about 173[22]), there will be a difference in the sweetness of a sweet wine made from a partially fermented must as compared to a wine made by the addition of sucrose or grape concentrate to a dry wine,[23] the former being appreciably sweeter than the latter.

The determination of the levulose-dextrose ratio is a rough means of determining the nature and extent of the fermentation period of dessert wines, if produced from musts of moderate sugar concentration.

Muttelet[24] was unable to find sucrose in genuine Portuguese port wines, and Clavera and López[25] found none in similar samples of Malaga. There is abundant evidence that grapes of *Vitis vinifera* contain very little or no sucrose. Alwood[26] has shown that sucrose occurs in certain

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[20] Szabó, I., and L. Rakcsányi. Das Mengenverhältnis der Dextrose und der Lävulose in Weintrauben, im Most und im Wein. V^e Congrès International Technique et Chimique des Industries Agricoles Comptes Rendus 1:936–49. 1937.

[21] Parisi, E., M. Sacchetti, and C. Bruini. Sulla fermentazione alcoolica dei mosti concentrati. Annali di Chimica Applicata 22:616–20. 1932.

[22] Biester, Alice, M. M. Wood, and C. S. Wahlin. Carbohydrate studies. I. The relative sweetness of pure sugars. American Journal of Physiology 73:387–96. 1925.
For other data see:
Walton, C. F., Jr. Sweetening agents. Relative sweetening power. p. 357–58. *In:* Washburn, E. W. International critical tables. Vol. I. 415 p. McGraw-Hill Book Co., New York, N. Y. 1926.

[23] But invert sugar, the product of the hydrolysis of sucrose and containing equal amounts of dextrose and levulose, has a relative sweetness of about 127–130.

[24] Muttelet, C. F. Les sucres des vins de Ports. Annales des Falsifications et des Fraudes 23:205–7. 1930.

[25] Clavera, J. Mª., and M. O. López. Los azúcares y el extracto seco en los vinos do Málaga. Sociedad Española de Física y Química Anales 30:140–44. 1932.

[26] Alwood, W. B. Enological studies. U. S. Dept. Agr. Bur. Chem. Bul. 140:1–24. 1911.

native American species, but even in wines made wholly from such grapes the percentage of sucrose will be small. Since genuine California wines are practically always made from pure *V. vinifera* varieties and since, furthermore, the addition of any sweetening agent except grape concentrate is prohibited by California law, the presence of hydrolyzable sugars, such as sucrose, in California sweet dessert wines, is very strong evidence indeed of adulteration.

Kickton and Murdfield,[27] however, report a supposedly genuine Madeira wine containing over 3 per cent of sucrose. Practically all of their 240 samples, however, were free of sucrose. Kickton and Korn[28] also report sucrose in 13 out of 591 samples of sherries, all of which were presumably genuine.

Products Derived from Sugars.—When acid solutions containing hexose sugars are heated for a sufficiently long period or at a high enough temperature, a dehydration takes place and hydroxymethylfurfural $(CH_2O{-}\overbrace{C{=}CHCH{=}C}^{O}{-}COH)$ is formed. Boiled-down musts, and heated wines, such as California sherries, contain considerable amounts of this substance. Methods of testing for hydroxymethylfurfural are given on page 166. Jägerschmid[29] has used one of these methods for the determination of added caramel to brandies, while Kruisheer, Vorstman, and Kniphorst[30] and Botelho[31] have used the test to determine the adulteration of wines such as genuine Portuguese port, which are supposed to be made only with fresh grapes, with reduced musts or with caramel. Although hydroxymethlyfurfural is formed in honeys during storage, Kruisheer and co-workers did not find excessive quantities in a pure thirty-five-year-old wine. Further investigation of this point should be made, particularly of very sweet wines stored in small cooperage in warm cellars. Hydroxymethylfurfural has an agreeable odor like that of camomile. Its taste, however, is slightly bitter.[32]

Other products which Kruisheer and co-workers found in heated

[27] Kickton, A., and R. Murdfield. Herstellung, Zussammensetzung und Beurteilung des Madeiraweines und seiner Ersatzweine. Zeitschrift für Untersuchung der Nahrungs und Genussmittel 28:325–64. 1914.

[28] Kickton, A., and O. Korn. Herstellung, Zusammensetzung, und Beurteilung des Sherrys und seiner Ersatzweine. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel 47:281–328. 1924.

[29] Jägerschmid, A. Nachweis von Karmel in Wein, Kognak und Bier. Zeitschrift für Untersuchungen der Nahrungs- und Genussmittel 17:269. 1909.

[30] Kruisheer, C. I., Vorstman, and L. C. E. Kniphorst. Bestimmung von Oxyméthylfurfurols und des Lävulosins in Portwein und anderen Süssweinen. Zeitschrift für Untersuchungen der Lebensmittel 69:570–82. 1935.

[31] Botelho, L. C. Dosage de l'oxyméthylfurfurol dans le vin de Porto. Revue de Viticulture 89:202–5. 1938.

[32] Middendorp, J. A. Sur l'oxyméthylfurfurol. Recueil des Travaux Chimiques des Pays-Bas 38:1–71. 1919.

sweet wines or musts were levulinic acid ($CH_3C:OCH_2CH_2COOH$) and substances called *Lävulosins.* These are apparently dehydration products from levulose.[33]

Other investigators have been able to detect the use of raisins in wines by determining the fluorescence of the wines under ultraviolet light.[34]

2, 3-Butylene Glycol.—Although 2, 3-butlyene glycol does not seem to have any direct influence on the taste and aroma of wines (in pure solution it is practically odorless), its presence is of interest because the amount present seems to be correlated with the extent of the fermentation.[35] For this reason, wines fortified before the completion of their fermentation should contain reduced amounts of this substance, and such is the case. Kniphorst and Kruisheer found 40 to 80 mg of it for each per cent of alcohol in dry wines and only 3 to 15 mg for each per cent of alcohol in fortified wines. They did not however, find any acetylmethylcarbinol or diacetyl—the two successive stages in the oxidation of 2, 3-butylene glycol—in wines. Garino-Canina[36] also found reduced amounts of 2, 3-butylene glycol and confirms the fact that it is produced in proportion to the extent of fermentation in wines of low alcohol and in fortified wines. He has found acetylmethylcarbinol in wines fermented in the presence of acetaldehyde, and large amounts in vinegars. Parisi, Sacchetti, and Bruini (cited in footnote 21, p. 16) also found acetylmethylcarbinol in the products of a fermentation of grape concentrate with a *Zygosaccharomyces.*

Glycerin.—Since glycerin is a by-product of fermentation, the amounts of it found in dessert wines would be expected to be small owing to the reduced period of fermentation and to the dilution factor of fortification. Such is the case. The amounts found are smaller than those of most table wines, although unexpectedly large amounts are found in some dessert wines. The range reported is from 0.03 to 1.5 per cent.

The sweetness of dessert wines and their generally high specific gravity makes the influence of glycerin on the taste and texture of the wine less important than in table wines. In addition, since the restricted fer-

[33] Gisvold, Ole, and C. H. Rogers. The chemistry of plant constituents. 309 p. (See especially p. 41–42.) Burgess Publishing Co., Minneapolis, Minnesota. 1939.

[34] Szabó, I. Examination of wine by means of a quartz lamp. [Translated title.] Magyar Ampelol. Évkonyr 9:454–57. 1935. *Abstracted in:* Chemical Abstracts 30: 1506.

Canals, E., and H. Collet. Spectres de fluorescence des vins. Annales des Falsifications et des Fraudes 32:163–71. 1939.

[35] Joslyn, M. A. The by-products of alcoholic fermentation. Wallerstein Laboratories Communications 3(8):30–43. 1940.

[36] Garino-Canina, E. Il 2–3 butilenglicole e l'acetilmetilcarbinolo nei vini e negli aceti. Annali di Chimica Applicata 23:14–20. 1933.

mentation and use of fortifying brandy during production is generally recognized for all California dessert wines, the determination of glycerin in these wines is of minor importance. Furthermore, the recognition of the very marked influence of environmental conditions on the amount of glycerin formed has diminished its value in the detection of adulteration, even for table wines. Its concentration is, however, of value as an indication of the extent of fermentation.

Aldehydes.—Although small amounts of acetaldehyde are normally produced during fermentation, the largest amounts are apparently formed during aging. Amounts from 10 to 200 mg per liter are found in various types of California dessert wines. Normally the largest amounts—100 mg or over per liter—are found in sherries which have

TABLE 7

ACETALDEHYDE IN VARIOUS TYPES OF CALIFORNIA DESSERT WINES

Type	Samples	Volatile acidity		Sulfur dioxide		Acetaldehyde	
		Range	Average	Range	Average	Range	Average
	number	*per cent*	*per cent*	*p. p. m.*	*p. p. m.*	*p. p. m.*	*p. p. m.*
California sherry......	29	0.026–0.122	0.059	9.6– 99.4	33.9	14.9– 99.9	55.4
California dry sherry..	19	0.026–0 096	0.058	6.4–160.0	42.0	17.7–179 0	78.8

undergone a film-yeast fermentation. But considerable amounts are also found in California sherries (table 7) prepared by the baking process.

Acetals.—Trillat[37] found acetals to be present in wines and brandies. Acetals arise from the reaction of acetaldehyde and alcohols. They seem to be particularly important in wines of the sherry type, where the high content of aldehyde and alcohol favors their formation. The amounts found were small—150–190 mg per liter of wine.

Esters.—Numerous esters are found in wines. They are mainly ethyl esters. They range from the volatile esters of the low-molecular-weight acids, such as acetic, to the ethyl acid esters of acids, such as tartaric and malic. These latter esters have a boiling point above that of water. Esters are formed in wines through biological activity of yeasts and bacteria and through esterification during aging.

According to the early enologists, all esters were believed to have a marked influence on the desirable odors of wines.[38] More recent work indicates that for table wines, at least, only ethyl acetate is an im-

[37] Trillat, A. L'aldéhyde acétique dans le vin; son origine et ses effets. Institut Pasteur [Paris] Annales 22:704–19, 753–62, 876–95. 1908.

[38] Rocques, X. Le bouquet des vins. Revue de Viticulture 12:95–99. 1899.

portant factor in the aroma, and this mainly as a spoilage product.[39] In dessert wines the increased amount of alcohol should favor the increased production of all esters, and in fact aged dessert wines are markedly higher in esters. Rocques, for example, reported a very high concentration of esters in Madeira wines. As in table wines, the volatile neutral esters are undesirable, and if they amount to 200 mg per liter, the wine takes on a definitely spoiled character.

Tannin.—The tannins in wine are derived from the grape during fermentation, particularly from the skins, from the wood during aging, and by direct addition. The tannin derived from the wood is of little importance except in the case of white wines: Ribéreau-Gayon and Peynaud[40] have shown that white wines stored in barrels may gain in tannin. Garino-Canina[41] questions the importance of tannin from the grapes which are found in wines. He finds most of the reactions attributed to tannins to be due to the pigments in the wine, especially to oenin chloride. More recently, Nègre[42] has used the differential precipitation of total tanninlike material by lead acetate and the true tannin precipitated by zinc acetate to determine the amount of nontannin polyphenols present. He finds the latter are dissolved primarily in the early stages of fermentation while the oenotannins are dissolved by the alcohols primarily in the latter stages of fermentation. The significance of these results in fortification practices has not yet been determined. The tannins have an important effect on the taste of the wine and also influence its stability.

During the aging of wines, the tannin content gradually decreases, notably in red wines. The tannins are also important in wine because of their ability to precipitate proteins, and the tannin content is markedly reduced by fining agents such as gelatin. It is also slightly reduced by filtration through cellulose or asbestos. See page 59 for the chemical changes in red wines during aging.

Coloring Material.—The stability of color in red wines is very important. The color in *Vitis vinifera* grapes is due to anthocyanin pigments but no complete study of the nature of these pigments nor of the

[39] Ribéreau-Gayon, J., and E. Peynaud. Estérification chimique et biologique des acides organiques du vin. Société Chimique de France Bul. **3**(série 5):2325–30. 1936.

Peynaud, E. L'acétate d'éthyl dans les vins atteints d'acescence. Annales des Fermentation **2**:367–84. 1936.

[40] Ribéreau-Gayon, J., and E. Peynaud. Études sur le collage des vins (II). Revue de Viticulture **81**:53–59. 1934.

[41] Garino-Canina, E. Contribution to the study and to the determination of the tannins and the pigments of the grape. [Translated title.] Stazioni Sperimentali Agrarie Italiane **57**:245–74. 1924.

[42] Nègre, E. Contribution oenologique à l'études des matières tannöides. L'Académie d'Agriculture de France Comptes Rendus **25**:647–52. 1939.

influence of oxygen on them has been made. (See Bulletin 639, cited in footnote 4, p. 3.)

TYPES

No completely satisfactory system of nomenclature is available for California dessert wines. The use of foreign type names dates back to the time of the gold rush, although their continued use has been the subject of considerable criticism and polemics. The evolution of a system of naming which is free of objection would definitely be of considerable value, but the change must originate in the industry itself in view of the large commercial interests involved. All that can be attempted at present are some suggestions along this line.

With the exception of Angelica, which is apparently a native name,[43] and muscatel, which is derived from a varietal name, the type names of California dessert wines are derived from European wines. Satisfactory substitutes for type names such as port and sherry are difficult to find, even though it is known that the process of manufacture and the flavor of California sherry, for example, is so different from the Spanish that the California product bears little resemblance to its prototype.

The most logical development in nomenclature seems to be to restrict ordinary commercial wines to the following names:

I. Red, sweet dessert wines
- A. Without muscat flavor
  - 1. Full red color—*California port*
  - 2. Tawny color—was called *California tawny port* in the pre-Prohibition era
  - 3. *Trousseau port*—usually a tawny type and seldom produced since Repeal
- B. With muscat flavor—*red muscatel*

II. White, sweet dessert wines
- A. Without a rancio or cooked flavor
  - 1. Without muscat flavor
    - *a*) Amber or yellow color, high sugar content—*Angelica*
    - *b*) Water-white color—*California white port*
  - 2. With muscat flavor—*muscatel*
- B. With a rancio or cooked or caramel flavor
  - 1. Below 7 per cent sugar
    - *a*) 0–2.5 per cent sugar—*California dry sherry*
    - *b*) 4–7 per cent sugar—*California sweet sherry*
    - *c*) 0–4 per cent sugar—*California sherry*
  - 2. Above 3.5° Balling
    - *a*) With a pink tint—*California Tokay*
    - *b*) With an amber color—miscellaneous, poorly defined types

[43] Amerine, M. A., and A. J. Winkler. Angelica. Wines and Vines 19(9):5, 24. 1938.

New names could then be evolved for distinctive types or high-quality wines and a trade demand created for these products. Or, if a predominant varietal origin is established and the wine has a distinguishable varietal character, the varietal name might be used. This latter type of nomenclature, with the exception of muscats, is less important for dessert wines than for table wines; although, as indicated, a Trousseau port has been made in California and marketed as such.

California Port.—Port is the appellation originally used for the sweet fortified wines originating in the Douro district of Portugal. These are always red unless otherwise denoted. This port, which is mainly drunk in England, is aged in about 135-gallon oak casks from three to ten years, or more, before being sold as ruby port or as tawny port. The former has a red color while the latter has lost its pure red color with age and has assumed a brown-red hue. A limited quantity of the best wine in the best years is aged only a year or two in oak casks, is then bottled, and is called "vintage port;" such wines must be aged many years in the bottle before reaching maturity and, because of the heavy crusts which they throw, are decanted before serving. In Portugal there is no set chemical criterion for port as far as sugar content is concerned: some ports are made almost dry with only a few per cent of reducing sugar, while some are very sweet. Typical analyses of ports are given in table 8. The variability in composition is well illustrated by these figures. Botelho,[44] however, gives the following limits for the better port wines: alcohol, 17.0 to 22.2 per cent; total acid, 0.35 to 0.59 per cent; volatile acid, 0.025 to 0.090 per cent; extract, 10.1 to 14.3 per cent; reducing sugar, 8.1 to 11.2 per cent; levulose-dextrose ratio, 1.4 to 3.3. Rigid legislation controls the districts in Portugal within which port wines may be produced.[45]

"California port" is the name applied in this state to red, sweet dessert wines which have a Balling of over 5.5°. They have been made here since at least gold rush days. As table 8 indicates, the present-day commercial California port contains 17.7 to 21.3 per cent alcohol, 0.30 to 0.67 per cent total acid, 0.026 to 0.178 per cent volatile acid, 11.1 to 14.3 per cent extract, and an average of 10.6 per cent reducing sugar. California port has more acid than our muscatel or Angelica but it should not have more than 0.65 since the wine is then apt to be too tart.

The color of California ports varies widely. This is due to the difficulties encountered in producing well-colored ports from the miscellaneous varieties grown in this state and to the differences in the length and methods of fermentation and aging used. There is a well-defined trade

[44] Botelho, J. C. Études sur le vin de Porto. Annales de Chimie Analytique **17**: 49–63. 1935.

[45] Serra, E., and M. Rodriques. Legislação sôbre vinhos. 472 p. Emprêsa Jurídica Editora, Lisbon, Portugal. 1938.

TABLE 8
COMPOSITION OF RED SWEET WINES

Wine	Total acid*	Volatile acid†	Alcohol	Extract	Sugar	Tannin	Glycerin	Balling	Acetal-deyhde	pH	Neutral esters
	grams per 100 cc	*grams per 100 cc*	*volume per cent*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*degrees*	*mg per liter*	*pH*	*mg per liter*
California											
Pre-Prohibition, 67 samples:[a b c d]											
Maximum	0.70	0.144	22.2	17.2	15.1	0.13§	0.75§	—	—	—	—
Minimum	.35	.080	12.2	8.5	5.2	.05§	0.16§	—	—	—	—
Average	.48	.109‡	19.3	12.4	9.6	.07§	0.57§	—	—	—	—
Post-Prohibition, 64 samples:[e]											
Maximum	.67	.178	21.3	14.3	12.5	.16	1.40¶	8.4‖	119‖	4.08‖	541‖
Minimum	.30	.026	17.7	11.1	9.1	.04	0.34¶	5.8‖	21‖	3.60‖	176‖
Average	.47	.064	19.6	12.6	10.6	0.08	0.53¶	6.7‖	68‖	3.82‖	305‖
Portugal, 419 samples:[f g h]											
Maximum	.63	.097**	22.5	14.3	12.1	—	0.71††	—	—	—	—
Minimum	.25	.020**	14.4	6 5	3.8	—	0.21††	—	—	—	—
Average	0.43	0.058**	19.8	9.9	7.9	—	0.34††	—	—	—	—

* As tartaric.
† As acetic.
‡ Analysis of Wiley only.
§ No analysis of Kickton and Murdfield.
¶ 13 samples only.
‖ 25 samples only.
** Analysis of König and Botelho only.
†† Analysis of König only.

Sources of data:
[a] Bigelow, W. C. The composition of American wines. U. S. Bureau of Chemistry Bul. **59**:1–76. 1900.
[b] Wiley, H. W. American wines at the Paris Exposition. U. S. Bureau of Chemistry Bul. **72**:1–40. 1903.
[c] Krug, W. H. Results of analysis. *In:* Wetmore, C. A. Treatise on wine production. State Viticultural Commission Rept., 1893–94. Appendix B: 1–92. State Printing Office, Sacramento, Calif. 1894.
[d] Kickton, A., and R. Murdfield. Die Ersatzweine des echten Portweines. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel **27**:617–76. 1914.
[e] Amerine, M. A. Unpublished data from wines of the 1937 and 1938 California state fairs and of the 1939 Golden Gate International Exposition.
[f] König, J. Chemische Zusammensetzung der menschlichen Nahrungs- und Genussmittel. Vol. 1. 1535 p. J. Springer, Berlin, Germany. 1903.
[g] Botelho, J. C. Études sur le vin de Porto. Annales de Chimie Analytique **17**:49–63, 179–80. 1935.
[h] Kickton, A., and R. Murdfield. Herstellung, Zusammensetzung und Beurteilung des Portweines. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel **25**:625–75. 1913.

demand for moderately red, bulk port. Well-aged, bottled ports of the tawny-colored type were formerly fairly important in the California market, however, and may again be developed in the future. The less-sweet, lighter-colored ports may be used as appetizer wines before meals. The richer, darker ports and the well-aged tawny ports are dessert wines, more appropriately served after dinner. Special trade names should be developed for these quality, special-purpose wines.

Angelica.—The origin of the name Angelica is in doubt, but it apparently has been used continuously since Mission days. The type used to be the sweetest made in the state. Indeed, it originally resembled the fortified musts (*mistelles*) of France, Spain, and Italy, which are mainly used for blending. Since Repeal, there has been a tendency to allow the musts intended for Angelica to ferment before fortification. Table 9 shows that the present-day Angelica is not as sweet as the pre-Prohibition product, indeed, not any sweeter than muscatel (table 11). If it conformed more nearly to its fortified-must character, it would be still sweeter, averaging over 13 per cent reducing sugar or approximately 8° Balling. The wines of this type have a low total acid but should not be below 0.30, and for their best flavor probably should average 0.40 per cent or higher. Their color is golden, similar to that of the muscatels. They should be free of too much aldehyde aroma or of a distinguishable sherry or rancio character. Because of the uncomplicated, clean, rich, bland character of Angelica, it should not be a difficult wine to produce well.

The place of the Angelica has always been as a dessert wine. It finds some use in the winery for blending purposes. As to quality, the Angelica has little to recommend it. It is too sweet for proper aging, and it lacks any distinctive varietal character. Commercially, however, there is a demand for a very sweet white wine, which the Angelica admirably fills.

California White Port.—White port is occasionally produced in Portugal, but white varieties of grapes are used and it resembles a less-sweet, aged California Angelica, having a pleasing light-amber color and frequently a slight muscat flavor. It is limited in production and importance there.

California white port has been produced in California for many years for a limited market. Here, however, the wine usually has a water-white appearance. Such a color is not possible in normally produced and aged wines, and to secure it the use of decolorizing charcoal is necessary. In pre-Prohibition days animal charcoals were mainly used for the decolorization. Since Repeal, decolorizing charcoals of vegetable origin have been used for its preparation. The objections most commonly raised by the public to such a wine are: that it does not conform to any

TABLE 9

COMPOSITION OF CALIFORNIA ANGELICA

Wine	Total acid*	Volatile acid†	Alcohol	Extract	Sugar	Tannin	Glycerin	Balling	Acetaldehyde
	grams per 100 cc	*grams per 100 cc*	*volume per cent*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*degrees*	*mg per liter*
Pre-Prohibition, 8 samples:[abc]									
Maximum	0.35	0.065‡	21.6	19.3	16.9	0.04	0.94	—	—
Minimum	.16	.029‡	17.3	14.1	11.9	.02	0.13	—	—
Average	.30	.047‡	18.6	17.4	14.9	.03	0.56	—	—
Post-Prohibition, 33 samples:[d]									
Maximum	.56	.134	20.9	15.4	—	.09	1.16	9.9	179
Minimum	.26	.026	17.6	10.3	—	.02	0.48	6.8	39
Average	0.38	0.064	19.3	13.2	—	0.05	0.66	7.7	111

* As tartaric.

† As acetic.

‡ Analysis of Wiley only.

Sources of data:

[a] Bigelow, W. C. The composition of American wines. U. S. Bureau of Chemistry Bul. **59**:1–76. 1900.

[b] Wiley, H. W. American wines at the Paris Exposition. U. S. Bureau of Chemistry Bul. **72**:1–40. 1903.

[c] Krug, W. H. Results of analysis. *In:* Wetmore, C. A. Treatise on wine production. State Viticultural Commission Rept. 1893–94. Appendix B:1–92. State Printing Office, Sacramento, Calif. 1894.

[d] Amerine, M. A. Unpublished data from wines of the 1937 and 1938 California state fairs.

"natural" wine type; that it has no quality either of age or flavor; that it frequently has an undesirable taste owing to the use of excess amounts of charcoal; and that its manufacture invites the production and utilization of poor-quality grapes and off-flavor or -color, dessert wines. The propriety of such a dessert wine type, which resembles a "natural" dessert wine so little, may well be open to question.

The composition of some California white ports produced since Repeal is given in table 10. The analyses are fairly uniform and indicate a moderately sweet white wine. The average extract content is 10.3 per cent, which is somewhat lower than that of Angelica.

Muscatel.—Because of the aromatic varietal flavor, muscatel is one of the easiest of all varietal wines to recognize. The distinctive principle which gives this character is present in the grape and is carried over into the wine. Muscat wines are of very ancient origin, having been mentioned by Columella about 100 A.D.,[46] and are produced in practically every viticultural district in the world. Classic examples are the Malmsey of Madeira, the Frontignan of France, and the Samos of Greece. These wines are rich, luscious, and golden-colored. Most of the sweet muscat wines are fortified sometime during their production.

Muscatels have been made in California since the days of the Missions. Although not considered important from a quality standpoint in pre-Prohibition days, they have been very popular wines since Repeal. Because of the large acreage of the Muscat of Alexandria variety, there should be no difficulty in the production of this wine with the flavor and aroma which are characteristic of the grape. Only muscat grapes should be used to insure that all California muscatels will have the desirable characteristic varietal flavor. The present minimum requirement of 51 per cent muscat grapes is not high enough to yield muscatel with the desired flavor.

As shown in table 11, this is one of the sweetest of the dessert wines. The extract of the dealcoholized wine should average over 13 per cent. This means, if the alcohol content approximates 20 per cent, that the Balling of the wine will nearly always exceed 7°; and some commercial wineries maintain a standard nearer 8° Balling in the finished wine. The total acid is variable but averages rather low even for the dessert wines. Very late harvesting, overaging, overoxidation, or cooking frequently cause these wines to become brown and to lose their fresh fruity flavor. Since the flavor is one of their particular attractions, this should be avoided if possible. To summarize: the California muscatel should be a distinctively aromatic, golden wine exceeding 11 per cent sugar or 7° Balling. It is used exclusively as a dessert and after-dinner wine.

[46] Roy-Chevrier, J. Ampélographie rétrospective. 531 p. (See p. 73–74, 78.) Coulet et Fils, Montpellier, France. 1900.

TABLE 10

COMPOSITION OF CALIFORNIA AND PORTUGUESE WHITE PORTS

Wine	Total acid*	Volatile acid†	Alcohol	Extract	Sugar	Tannin	Glycerin	Acetaldehyde	Balling
	grams per 100 cc	*grams per 100 cc*	*volume per cent*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*mg per liter*	*degrees*
California, post-Prohibition, 20 samples:[a]									
Maximum	0.48	0.088	20.5	14.2	—	0.07	0.80	217	8.4
Minimum	.27	.018	18.0	10.8	—	.02	.35	64	6.2
Average	.33	.043	19.6	12.7	10.6	0.03	0.50	138	7.2
Portugal, 136 samples:[bc]									
Maximum	.56	.090‡	22.5	14.7	13.0	—	—	—	—
Minimum	.27	.020‡	15.5	6.4	4.5	—	—	—	—
Average	0.41	0.046‡	19.6	10.3	8.3	—	—	—	—

* As tartaric.

† As acetic.

‡ Analysis of Botelho only.

Sources of data:

[a] Amerine, M. A. Unpublished data from 1937 and 1938 California state fairs.

[b] Kickton, A., and R. Murdfield. Herstellung, Zusammensetzung und Beurteilung des Portweines. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel **28**:625–75. 1913.

[c] Botelho, J. C. Études sur le vin de porto. Annales de Chimie Analytique **17**:49–63. 1935.

TABLE 11

COMPOSITION OF VARIOUS MUSCAT WINES

Wine	Total acid*	Volatile acid†	Alcohol	Extract	Sugar	Tannin	Glycerin	Acetal-dehyde	Sulfur dioxide (total)	pH	Balling	Neutral esters (total)
	grams per 100 cc	*grams per 100 cc*	*volume per cent*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*mg per liter*	*mg per liter*	*pH*	*degrees*	*mg per per liter*
California:												
Pre-Prohibition, 9 samples:[abc]												
Maximum	0.49	0.124‡	21.5	19.7	16.8	0.04	1.01	—	—	—	—	—
Minimum	.20	.068‡	13.9	16.8	13.2	.02	0.05	—	—	—	—	—
Average	.37	.093‡	18.6	17.9	15.2	.03	0.65	—	—	—	—	—
Post-Prohibition, 55 samples:[d]												
Maximum	.52	.144	20.9	17.9	14.4	.09	0.75§	175§	131 §	4.20§	12.5§	404§
Minimum	.27	.022	17.4	11.8	8.9	.01	0.39§	44§	0.0§	3.63§	6.6§	143§
Average	.37	.061	19.4	13.5	11.4	.05	0.57§	99§	33 §	3.92§	8.0§	248§
Greece, 24 samples:[e]												
Maximum	.78	.160¶	18.7	26.3	22.4	—	1.43	—	—	—	—	—
Minimum	.34	.044¶	11.2	12.6	8.2	—	0.02	—	—	—	—	—
Average	.56	.089¶	15.0	18.7	14.9	—	0.57	—	—	—	—	—
Italy, 41 samples:[ef]												
Maximum	.71‖	.177	18.9‖	21.4‖	17.2‖	—	1.28	—	—	—	—	—
Minimum	.46‖	.067	12.6‖	6.0‖	?‖	—	0.76	—	—	—	—	—
Average	0.60	0.101**	17.4	17.7	14.9	0.03††	0.96‡‡	—	—	—	—	—

* As tartaric.
† As acetic.
‡ Analysis of Wiley only.
§ 16 post-Prohibition California samples only.
¶ Range and average of 13 samples.
‖ Range on 14 samples.
** Volatile acid on 7 samples.
†† Tannin on 27 samples.
‡‡ Glycerin on 6 samples.

Sources of data:
[a] Bigelow, W. C. The composition of American wines. U. S. Bureau of Chemistry Bul. **59**:1–76. 1900.
[b] Wiley, H. W. American wines at the Paris Exposition. U. S. Bureau of Chemistry Bul. **72**:1–40. 1903.
[c] Krug, W. H. Results of analysis. *In*: Wetmore, C. A. Treatise on wine production. State Viticultural Commission Rept. 1893–94. Appendix B: 1–92. State Printing Office, Sacramento, Calif. 1894.
[d] Amerine, M. A. Unpublished data from wines of the 1937 and 1938 California state fairs and of the 1939 Golden Gate International Exposition.
[e] König, J. Chemische Zusammensetzung der menschlichen Nahrungs- und Genussmittel. Vol. 1. 1535 p. J. Springer, Berlin, Germany. 1903.
[f] Sannino, F. A. Trattato completo di enologia. Vol. I. 482 p. V. Bona, Torino, Italy. 1920.

California Sherry.—The origin of this type name is obviously Spain, but the method of production utilized here more closely resembles that used in Madeira.[47] Sherry of the drier types as produced in Spain during the last century and a half has involved a maturation in contact with a film yeast (called the *flor* in Spain) combined with aging in a solera system. The film-yeast stage results in the production of a considerable amount of aldehydes and other flavoring constituents. The solera system (see p. 99) is really a complicated system of blending in which casks of similar types of wine but of different ages are placed in a series. Mature wine is drawn from the oldest cask, which is then filled from the next oldest, and each succeeding cask is filled from the next oldest. A good solera may contain as many as ten stages. The sweeter and more alcoholic types of Spanish sherries are also aged in a solera system for a number of years, but they do not usually pass through a film-yeast ("flowering") stage; although some wine which has undergone the film-yeast stage may be blended with the sweeter types of wines before bottling to give them more character. Analyses of typical Spanish wines are given in table 12. The composition of the various Spanish types is not at all uniform, particularly with respect to the alcohol content. This variability arises from the fact that fortification, if made, is carried out in unequal steps, depending on the quality of the wine, and also from the apparent fact that certain Spanish sherries increase in alcohol content during storage. (See p. 15.)

Wines of a similar type are produced by analogous processes in Australia and South Africa, and Schanderl[48] has indicated the general utility of the film yeasts for this purpose. Hohl and Cruess[49] have demonstrated that the process is applicable in California. Although sherries produced by film yeasts will undoubtedly be of increasing importance in California, there is no indication that the shift to this process will be very rapid. The usual baking process will probably continue to be the major method of production used in this state for some time to come. When properly made and aged, the product made by baking is a distinctive type of wine.

California sherries at the present time are wines of about 20 per cent alcohol which have been baked two to four months at 120° to 140° F. They should be nearly dry or only slightly sweet (not over 4 per cent reducing sugar) in taste. California sherries with below about 2½ per

[47] Castella, F. de. Madeira. Victoria Department of Agriculture Journal **26**:577–87. 1928.

[48] Schanderl, H. Untersuchungen über sogenannte Jerez-Hefen. Wein und Rebe **18**:16–25. 1936.

[49] Hohl, L. A., and W. V. Cruess. Observations on certain film-forming yeasts. Zentralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten **101**: 65–78. 1939.

TABLE 12

COMPOSITION OF CALIFORNIA AND SPANISH SHERRY AND MALAGA

Wine	Total acid*	Volatile acid†	Alcohol	Extract	Sugar	Tannin	Glycerin	Acetaldehyde	Sulfur dioxide (total)	pH	Balling	Neutral esters
	grams per 100 cc	*grams per 100 cc*	*volume per cent*	*grams per cent*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*mg per liter*	*mg per liter*	*pH*	*degrees*	*mg per liter*
California, dry sherry, post-Prohibition, 49 samples:[a]												
Maximum	0.61	0.168	21.8	7.0	4.32	0.09	1.12	179	160	4.18	−0.7	497
Minimum	.29	.026	18.6	3.2	0.88	.02	0.80	18	6	3.35	−3.2	211
Average	.43	.077	19.8	4.7	2.46	.05	0.96‡	79‡	42‡	3.80‡	−2.0‡	335‡
California, sherry:												
Pre-Prohibition, 25 samples:[bcdef]												
Maximum	.80	.107	21.8	10.9	8.87	.06	0.72¶	—	—	—	—	—
Minimum	.38	.013	13.7	2.8	1.20	.03	0.32¶	—	—	—	—	—
Average	.53	.040§	18.6	6.3	4.08	.04	0.68¶	—	—	—	—	—
Post-Prohibition, 93 samples:[ag]												
Maximum	.56	.132	22.2	8.4	4.49	.09	1.67	100	99	4.00	+0.7	730
Minimum	.32	.026	18.0	3.9	1.32	.03	0.83	15	10	3.41	−3.7	226
Average	.41	0.067	19.9	5.5‖	3.30‖	0.05‖	1.02**	55**	34**	3.80**	−1.1**	419**
Spain:												
Sherry, 616 samples:[ef]												
Maximum	.82	—	24.3	20.7	17.9	—	0.99¶	—	—	—	—	—
Minimum	.25	—	14.1	1.7	0.1	—	0.14¶	—	—	—	—	—
Average	.44	—	27.4	5.1	2.9	—	0.51¶	—	—	—	—	—
Malaga, 40 samples:[e]												
Maximum	.81	—	20.3	30.3	25.2	—	1.06	—	—	—	—	—
Minimum	.24	—	11.5	15.0	11.9	—	0.14	—	—	—	—	—
Average	0.51	—	15.9	22.1	18.3	—	0.55	—	—	—	—	—

* As tartaric.
† As acetic.
‡ On 19 samples of post-Prohibition California dry sherry.
§ Only 9 volatile acid analyses.
¶ No analysis of Kickton and Korn.
‖ No analysis of Joslyn.
** On 29 samples of post-Prohibition California sherry.

Sources of data:

[a] Amerine, M. A. Unpublished data from wines of the 1937 and 1938 California state fairs and of the 1939 Golden Gate International Exposition.
[b] Bigelow, W. C. The composition of American wines. U. S. Bureau of Chemistry Bul. **59**:1–76. 1900.
[c] Wiley, H. W. American wines at the Paris Exposition. U. S. Bureau of Chemistry Bul. **72**:1–40. 1903.
[d] Krug, W. H. Results of analysis. *In:* Wetmore, C. A. Treatise on wine production. State Viticultural Commission Rept. 1893–94. Appendix B: 1–92. State Printing Office, Sacramento, Calif. 1894.
[e] König, J. Chemische Zusammensetzung der menschlichen Nahrungs- und Genussmittel. Vol. 1. 1535 p. J. Springer, Berlin, Germany. 1903.
[f] Kickton, A., and O. Korn. Herstellung, Zusammensetzung, und Beurteilung des Sherrys und seiner Ersatzweine. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel **47**:281–328. 1924.
[g] Joslyn, M. A. Electrolytic production of rancio flavor in sherries. Industrial and Engineering Chemistry, industrial edition **30**:568–77. 1938.

cent reducing sugar are considered to best represent the California dry-sherry type. Sherries of 2½ to 4 per cent sugar taste sweet and are commonly sold as California sherry. The proposed new standards for California sherries set the maximum sugar content for the class at 7 per cent; dry sherries to contain 0 to 2½ per cent; sweet sherries 4 to 7 per cent. As indicated in table 12, there is considerable unnecessary overlapping of composition between these types at the present time, and the limits of sugar concentration suggested above might be more uniformly utilized. The present maximum limit of 4 per cent sugar is likewise poorly enforced: a number of California sherries exceed this limit.

The color of California sherries should be a pale amber. Darker wines are usually of poorer quality due to baking at too high a temperature or aging too long in small cooperage. Light-colored types can sometimes be produced by baking at a lower temperature or by the use of charcoal. The latter procedure would be undesirable even if it were permitted.

Miscellaneous Wine Types.—The commercial production of the California Tokay, Madeira, Marsala, Malaga, and similar types has been very small in this state. Furthermore, there has been little unanimity of opinion within the industry as to what each type should represent. Certain of these types have been produced by the addition of reduced must, while others are sherry-flavored blends. If there is a demand for a sweet wine to which reduced must has been added, the development of a new name would be advisable, since the California wines made by this procedure do not closely resemble their European prototypes.

The variability in composition of these types when produced in their original home is considerable (table 13), but the wines within each type retain their similarity owing to the process of production—Madeiras, owing to their baking; Marsalas, owing to the addition of reduced must; and Malagas, owing to the very sweet grapes used as well as to the addition of reduced musts. The use of these type names for California wines is confusing. If wines of related characteristics are produced, they should be given a new and distinctively California name.

The California Tokay is an entirely different product from the Hungarian Tokay. This latter wine is a natural, sweet, unfortified wine largely produced from the Furmint grape. The California wine is a fortified sweet wine and is almost always a blended wine. It is not ordinarily produced with the Flame Tokay grape, for this grape is ill-suited to the production of a sweet dessert wine because of its low sugar content. Most California Tokays are a blend of Angelica, California port, and California sherry. Only enough port is used to give the wine a pink tinge. The sherry reduces the sugar content of the Angelica and gives

TABLE 13

COMPOSITION OF MARSALA AND MADEIRA AND CALIFORNIA MADEIRA, MARSALA, AND TOKAY WINES

Wine	Total acid*	Volatile acid†	Alcohol	Extract	Sugar	Tannin	Glycerin	Balling
	grams per 100 cc	*grams per 100 cc*	*volume per cent*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*degrees*
Marsala:								
California, post-Prohibition, 11 samples:[a]								
Maximum	0.56	0.088	20.6	13.7	—	0.09	—	—
Minimum	.32	.050	18.7	6.9	—	.04	—	—
Average	.43	.060	19.3	9.5	—	.06	—	—
Italian, 93 samples:[b]								
Maximum	.63‡	.230‡	20.8§	10.7‡	8.24‡	—	1.24‡	—
Minimum	.40‡	.070‡	17.1§	4.1‡	2.67‡	—	0.30‡	—
Average	.54	.140	16.1	5.3	3.90	—	0.72	—
Madeira:								
California, post-Prohibition, 11 samples:[a]								
Maximum	.48	.122	20.3	14.3	—	.08	—	6.3
Minimum	.28	.044	18.3	3.8	—	.04	—	1.3
Average	.37	.077	19.3	9.1	—	.05	—	3.8
Portuguese, 253 samples:[bc]								
Maximum	.80	.187¶	22.3	19.2	16.38	—	1.04‖	—
Minimum	.30	.104¶	13.7	2.9	0.87	—	0.48‖	—
Average	.57	.143	18.3	6.6	4.36	—	0.71	—
California Tokay,** post-Prohibition, 32 samples:[a]								
Maximum	.60	.136	20.4	14.3	—	.11	0.79	8.1
Minimum	.31	.032	17.0	8.1	—	.03	0.56	3.5
Average	0.41	0.071	19.2	11.6	—	0.06	0.64	5.9

* As tartaric.

† As acetic.

‡ Range on 16 samples only.

§ Range and average on 4 samples only.

¶ Range and average on 16 samples only, average of 23 samples was 20.8.

‖ Range and average of 25 samples only.

** The Hungarian Tokay is an entirely different type of wine, not being fortified, etc. Comparative analyses are therefore unnecessary.

Sources of data:

[a] Amerine, M. A. Unpublished data from wines of the 1937 and 1938 California state fairs.

[b] König, J. Chemische Zusammensetzung der menschlichen Nahrungs- und Genussmittel. Vol. 1. 1535 p. J. Springer, Berlin, Germany. 1903.

[c] Kickton, A., and R. Murdfield. Herstellung, Zusammensetzung und Beurteilung des Madeiraweines und seiner Ersatzweine. Zeitschrift für Untersuchung der Nahrungs- und Genussmittel **28**:325–64. 1914.

the wine a slight rancio flavor. The analyses in table 13 indicate the present-day California Tokays to be sweeter than California sherry and less sweet than Angelica. This wine lacks distinctiveness and is usually not of as high a quality as are the other dessert wines.

Vermouth and Related Types.—Two varieties of vermouth are commonly produced in Europe: the sweeter Italian type and the drier French type. Vermouths are made with a white wine base. Various herbs may be added directly to the wine and, after a period of leaching, the wine is filtered off the herbs; or an alcoholic extract of the herbs is made and added to the wine later. The mixture of herbs (see p. 123) gives the wine a slightly bitter and aromatic taste. Vermouth is used in Europe primarily as an appetizer wine and in this country chiefly for cocktails. Analyses of both types of vermouth are given in table 14.

Numerous other appetizer wines are made in Europe with bitter or aromatic principles incorporated into the red or white wine. Some contain quinine or related substances and are decidedly bitter. They are consumed in France in the same fashion that cocktails are here. Analyses of two common types are given in table 14.

Concentrates and Reduced Musts.—Grape concentrates are made by heating the must in a vacuum pan so that the water boils off at a low temperature. The sugar is concentrated to 65–80 per cent by this process, and usually, but not always, these concentrations of sugar prevent yeast fermentation. Concentrates are sold for industrial purposes where a liquid dextrose-levulose mixture is desired and also are used in wineries (see p. 40 and 111) for blending purposes.

Boiled-down grape juice, sometimes called "reduced must," is made by heating grape must in open pans, either by direct fire or on steam baths. In the first case, the caramelization and browning will be intense, while, in the second, the changes will be less pronounced. These products are used almost entirely by wineries.

PRINCIPLES OF DESSERT-WINE MAKING[50]

VARIETIES

As we shall indicate in the next section, the intelligent vinification of dessert wines requires that there be sufficient sugar in the must. Even the dry dessert wines, such as California sherries, profit by having a higher percentage of sugar in the must than would be suitable for dry table wines. The greater this sugar concentration, within the limits under which the grapes retain a suitable character, the less will be the amount of alcohol required for fortification. In some cases there is also a better

[50] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 171–72.

TABLE 14

COMPOSITION OF VERMOUTH AND RELATED TYPES

	Total acid	Volatile acid	Alcohol	Extract	Sugar	Tannin and coloring matter	Glycerin	Essential oils
	grams per 100 cc	*grams per 100 cc*	*volume per cent*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*
Aromatic wines:[a]								
No. 1*	0.49	0.042	18.1	13.7	11.4	0.12	0.46	—
No. 2	.47	.041	16.2	18.8	16.5	.15	.90	0.028
French vermouth:[a]								
No. 1†	.65	.060	18.2	6.8	4.1	.07	.25	.015
No. 2	.53	.098	16 5	6.4	3.7	0.01	.30	.018
No. 3	.65	.060	15.9	7.8	5.7	—	.12	0.033
Italian vermouth:[b]								
142 samples	0.40‡	0.072	15.9	17.4	15.4	—	0.59	—

* An important and well-known aromatic wine.

† A famous French vermouth.

‡ The ranges in composition were as follows: total acid, 0.19–0.60; volatile acid, 0.002–0.222; alcohol, 12.2–19.1; extract, 7.5–23.3; reducing sugars, trace–20.3 (sucrose was reported in many samples); glycerin, 0.03–1.13.

Sources of data:

[a] Garino-Canina, E. Vini aperitivi francesi. Regia Stazione Enologica Sperimentale di Asti Annuario (serie II) I:223–33. 1934.

[b] Scurti, F., and F. Tacchini. Sulla composizione dei vermouth Piemontesi. Stazione Sperimentale Agrarie Italiene **49**:299–313. 1916.

development of varietal flavor in the grape when the fruit is fully ripe. Satisfactory varieties for dessert wines not only should be as sweet as possible, but also should not be too acid. Some varieties are too high in acid, even at advanced maturity, for producing dessert wines. (See citation in footnote 13, p. 13.) In addition, the variety should have the flavor and color requisite for the type of wine for which it is to be used. Naturally its viticultural characteristics, such as production and disease resistance, must be favorable if it is to be grown profitably.

Effect of Environmental Conditions.—The desirability of a given variety will depend not only on its inherent character and composition

TABLE 15

Suggested Composition of Musts Destined for Dessert Wines

Type	Balling	Total acid as tartaric	pH	Minimum $\frac{\text{Balling}}{\text{acid}}$
	degrees	*grams per 100 cc*	*pH*	*ratio*
Angelica	>26.0	0.50–0.65	<4.00	40
Muscatels	>26.0	.50– .65	<4.00	40
Dry whites	24.0–28.0	.50– .65	<4.00	37
Red sweet	25.0–29.0	0.50–0.65	<4.00	38

but also on certain environmental conditions under which it is grown. Among these are the climate and the seasonal and soil conditions. The warmer districts are generally conceded to be the most desirable for grapes destined for sweet wines. In California this means the warm interior-valley area and the viticultural areas south of the Tehachapi Mountains. Even varieties which normally are used for table wines when grown in a sufficiently cool district may be utilized for dessert wines when grown in a warmer district. Some varieties of dessert-wine grapes may, however, be grown in the cooler districts and still find a satisfactory usage in dessert wines, especially in the warm seasons. This is particularly true for red dessert wines, for grapes grown in the cooler locations are richer in coloring matter than those grown in the warmer districts.[51] And some varieties may be used either for table or for dessert wine, according to the seasonal conditions and the time of picking. The varietal recommendations listed below refer only to grapes produced under conditions at least as warm as those of Lodi and Davis. In table 15 are given some suggestive limits for the composition of musts destined for dessert wines. (See also Bulletin 639, cited in footnote 4, p. 3.)

Muscat-flavored Varieties.—The Muscat of Alexandria is the domi-

[51] Winkler, A. J., and M. A. Amerine. What climate does—the relation of weather to the composition of grapes and wine. The Wine Review 5(6):9–11; (7):9–11, 16. 1937.

nant muscat-flavored variety planted in California. Wines made from this variety have a distinctive or even a strong varietal aroma. There is not only a large supply of this variety available, but also, in general, it can be obtained in a good condition at reasonable prices. Some objection may be raised to the variety because of (*a*) the lack of refinement in its wine, (*b*) the extreme raisining which occurs in years of small crop or during a particularly hot season, and (*c*) the ease with which its musts spoil. The lack of refinement in aroma and flavor appears to be an inherent quality of the variety. The extremely low total acid and very high pH of musts from this variety, notably in grapes picked late in

TABLE 16

Analyses of Muscat-flavored Grape Varieties, Davis

Variety	Period tested	Average date of harvesting	Balling	Total acid	pH	Balling / acid	Quality of wine
	years		*degrees*	*grams per 100 cc*	*pH*	*ratio*	
Aleatico	5	Oct. 1	28.5	0.57	3.59	50.0	Fair, lacks color
Malvasia bianca	5	Sept. 26	26.2	.49	3.72	53.5	Good
Muscadelle	6	Sept. 27	27.6	.66	4.03	41.8	Good
Muscat Canelli	3	Sept. 26	27.8	.57	3.65	48.8	Very good
Muscat Hamburg	6	Oct. 12	25.5	.59	3.85	43.3	Fair, lacks color
Muscat of Alexandria	6	Oct. 25	25.5	.47	3.81	54.3	Fair
Muscat St. Laurent	3	Sept. 26	26.7	.38	3.83	70.3	Fair
Orange Muscat	4	Oct. 9	25.8	0.49	3.87	52.6	Good

the season, partially accounts for the frequent spoilage of its musts.

The Muscat Canelli (Muscat Frontignan in France) is, from the flavor standpoint, more desirable than the Alexandria. It is unfortunately a small producer, ripens very early, sunburns easily, and is available only in small quantities. The wine is, however, of appreciably higher quality, being much fruitier and better balanced than that of the Muscat of Alexandria as well as being of a more distinctive flavor. Malvasia bianca is also a promising muscat-flavored variety. Its wine is distinctively flavored and the vines are fair producers. Moreover, it does not sunburn easily, although it becomes very high in sugar. The wine of the Orange Muscat is also distinctively flavored and the vines produce well.

The Muscat Hamburg and Aleatico are the chief red grapes with a muscat flavor planted in California. The wines of these varieties usually are too light in color to be used by themselves and must be blended with deeper-colored types. Of the two, the Aleatico has a more refined aroma and flavor.

Table 16 gives some comparative analyses of the various muscat-flavored varieties.

Varieties for White, Sweet Dessert Wines.—The chief types of white,

sweet dessert wines are Angelica and the California white port. The characteristic of these wines is that they have a large residual sugar content. Grapes destined for these wines must therefore have a high sugar concentration, as is indicated in table 15.

Thompson Seedless (Sultanina), Mission, and Grenache (when it is fermented off the skins), are the most important varieties ordinarily utilized for these wines in California. The best-quality wine appears to be that of the Mission, the product having a fruity flavor and a desirable smooth texture. The musts from Grenache are sometimes too colored

TABLE 17

Analyses of Grape Varieties Commonly Used for Angelica, Davis

Variety	Period tested	Average date of harvesting	Balling	Total acid as tartaric	pH	Balling / acid	Quality of wine
	years		*degrees*	*grams per 100 cc*	*pH*	*ratio*	
Black Prince*	3	Sept. 19	25.1	0.43	4.22	58.3	Fair, distinct
Erbalus di Caluso	5	Oct. 7	23.3	.67	3.42	35.0	Fruity, tart
Grenache†‡	5	Sept. 28	24.4	.45	3.77	54.3	Good
Grillo	3	Oct. 3	26.8	.55	3.46	48.7	Fair, fruity
Mission†‡	6	Sept. 25	25.6	.38	3.91	67.3	Very good
Sauvignon vert‡	6	Sept. 10	23.7	.52	2.95	45.6	Fair, distinct
Thompson Seedless	2	Oct. 9	26.3	.54	3.72	48.7	Fair
Verdelho	5	Sept. 16	24.9	0.67	3.72	37.2	Good

* Davis, Lodi, and Fresno averaged.
† Skin pigmented but white musts are obtainable by careful harvesting and rapid crushing and pressing.
‡ Davis and Fresno averaged.

for use in a white wine. The Thompson Seedless is used mainly because of its availability but is not regarded with favor by the industry. When properly matured, it produces merely a neutral-flavored must and wine.

Other varieties that are not commonly used in California but which attain a high degree of sugar include: Erbalus di Caluso, Sauvignon vert, Grillo, and Verdelho. Analysis of varieties which may be used for this type of wine are given in table 17.

Varieties for White, Dry Dessert Wines.—California sherry and related wines of less than 6 per cent sugar are included in the white, dry, dessert wines, commonly used as appetizer wines. As indicated in table 15, these types of wines do not require as high a sugar content in the must as do other types of dessert wines. Varieties which are naturally not so high in sugar, as well as the usual varieties when picked somewhat earlier, may be used. In any case, however, the Balling-acid ratio should not be below 35 nor should the total acidity exceed 0.60 or 0.65 at the most. Wines with a higher extract content may be made by using musts of high sugar content, if the fermentation is controlled so that it does not stick before the sugar content is sufficiently reduced.

Rocques reports[52] the Palomino to be the most important variety in the sherry district of Spain, with only small quantities of the Mantuo de Pilo, Mantuo Castellano, and Perruno. Some Pedro Ximénès is planted but the chief locale for this variety in Spain is in the Malaga district.

The most important varieties which are used for these types of wines in California are Palomino, Thompson Seedless, Mission (when it is fermented off the skins), Feher Szagos, Flame Tokay, and Malaga. The last two varieties are much less satisfactory, since they are ordinarily

TABLE 18

ANALYSES OF GRAPE VARIETIES COMMONLY USED FOR WHITE, DRY DESSERT WINES, DAVIS

Variety	Period tested	Average date of ripening	Balling	Total acid	pH	Balling / acid	Quality of wine
	years		*degrees*	*grams per 100 cc*	*pH*	*ratio*	
Boal di Madeira	5	Oct. 1	23.8	0.58	3.78	41.1	Good
Burger	2	Sept. 21	22.0	.68	3.59	32.2	Poor, thin
Feher Szagos*	4	Sept. 5	22.1	.39	3.42	56.5	Fair, if grapes clean
Flame Tokay†	5	Oct. 7	19.6	.45	3.54	43.5	Poor
Green Hungarian	2	Sept. 29	19.6	.40	——	49.0	Fair
Inzolia bianca	5	Oct. 4	23.9	.49	3.91	48.7	Good
Malaga	3	Oct. 25	20.0	.46	3.80	43.5	Poor
Malmsey	3	Oct. 17	24.4	.49	3.77	51.5	Good
Mission‡	6	Sept. 25	25.6	.38	3.91	67.3	Good
Palomino	5	Oct. 4	24.0	.46	4.13	52.2	Very good
Thompson Seedless	2	Oct. 9	26.3	0.54	3.72	48.7	Fair

* For Fresno.
† Davis and Lodi averaged.
‡ Davis and Fresno averaged.

below the minimum sugar requirements (table 18). The Feher Szagos rots badly in many vineyards, and in such cases it, too, is undesirable. Muscat wines have occasionally been used for California sherries. The muscat flavor partially remains even after baking. For this reason, their use in regular sherries should be avoided. But the development of a distinctively flavored sherry containing Muscat wine, properly named, would very possibly be desirable.

Varieties for Red, Sweet Dessert Wines.—California port is the only common red dessert wine produced in this state. It requires musts of high sugar content, but the grapes should be free of overripe or raisin flavors.

In the pre-Prohibition era, Trousseau was considered to be the best variety. Its wines are fruity and smooth but usually are deficient in

[52] Rocques, X. Les vins de liqueur d'Espagne. Revue de Viticulture 19:446–53. 1903.

color. This difficulty was formerly overcome by marketing the aged Trousseau wine as tawny-colored port. Post-Prohibition requirements have been so largely for highly colored ports that blending has usually been resorted to in order to increase the color, and the desirable qualities of the Trousseau wine have thus been masked.

The varieties commonly used to increase the color have been the Alicante Bouschet, Alicante Ganzin, Grand noir, and Salvador. Only the first and last of these four varieties are available in large quantities. The Alicante Bouschet is undesirable because of its flavor and its tendency to deposit its color during aging. The Salvador is satisfactory for blending when used in minimum amounts. It is somewhat darker than the Alicante Bouschet and has a slight fruity, aromatic flavor which may be undesirable in ports.

Other varieties commonly used are the Carignane, Petite Sirah, and Zinfandel. The Carignane makes only an ordinary-quality dessert wine. The Petite Sirah is useful if the grapes do not sunburn too much. The Zinfandel produces a desirable, distinctively flavored, fruity wine, but unfortunately, the condition of Zinfandel grapes produced in the warm interior districts is usually unsatisfactory, particularly with respect to bunch rot.

Other varieties not commonly used but which have desirable qualities for this type of wine are the Tinta Madeira and Valdepeñas. Muscats should not be used in California port. The development of red muscatels, however, is a satisfactory innovation, particularly the fortified Aleatico which has a pleasing fruity flavor. The composition of typical varieties used for the production of California port is given in table 19.

According to de Castella,[53] the most important varieties for port in Portugal are Alvarelhão, Bastardo, Touriga, and Tinta Cão. Only very limited amounts of any of these varieties have been planted in California with the possible exception of the Bastardo, which Olmo[54] believes to be very similar to or the same as the Trousseau. A test of these varieties may reveal some to be of value in California.

VINIFICATION

Dessert wines may be made from partly or wholly fermented musts or from unfermented grape juice. The extent to which they are fermented varies with the initial Balling degree of the must and the type of wine to be made. The fortification of practically unfermented free-run must drawn off the pomace does not yield wines of as good a flavor as those produced by the fortification of slightly fermented wines.

[53] Castella, F. de. Notes on Portuguese varieties of grapes. Victoria Department of Agriculture Journal 14:398–408, 565–70, 622–28, 673–86, 731–40. 1916.

[54] Olmo, H. P. Le Trousseau et le Bastardo. Revue de Viticulture 87:174–75. 1937.

Possible Use of Concentrate.—Sweet wines which derive their sweetness from the unfermented sugar remaining in the wine after the fermentation has been checked by the addition of fortifying brandy are superior in flavor to those prepared by the addition of grape concentrate to a dry wine. It has been claimed that the latter wines are fuller-bodied and more fruity than those made by the normal process. This is not true in general, although the use of concentrate for the amelioration

TABLE 19

ANALYSES OF GRAPE VARIETIES COMMONLY USED FOR CALIFORNIA PORT, DAVIS

Variety	Period tested	Average date of ripening	Balling	Total acid as tartaric	pH	Balling / acid	Color intensity*	Quality of wine
	years		*degrees*	*grams per 100 cc*	*pH*	*ratio*		
Alicante Bouschet....	5	Oct. 8	21.6	0.60	3.74	36.2	457	Poor
Alicante Ganzin......	3	Oct. 7	24.1	.71	3.54	33.9	558	Fair for color
Cinsaut..............	3	Sept. 28	25.3	.49	3.76	51.6	130	Good but lacks color
Carignane............	6	Oct. 9	23.4	.63	3.71	37.2	211	Fair in warm years
Grand noir†..........	3	Oct. 6	23.3	.53	3.78	44.0	277	Poor
Mourisco preto.......	5	Oct. 11	23.8	.58	3.97	41.0	175	Good but lacks color
Pagadebito...........	5	Sept. 29	22.4	.42	4.04	53.5	461	Fair, little flavor
Petite Sirah..........	6	Sept. 20	27.2	.73	3.61	37.3	637	Too tart and sunburns
Petite Bouschet......	3	Oct. 4	25.2	.49	3.73	51.4	421	Fair
Tinta Madeira........	5	Oct. 14	25.9	.57	3.81	45.5	206	Good, distinct
Trousseau............	6	Sept. 30	29.1	.56	4.09	52.5	165	Good, lacks color
Salvador‡............	6	Aug. 28	24.5	.79	3.70	31.2	1,430	For color only
Valdepeñas...........	6	Sept. 26	24.3	.55	3.87	44.2	191	Good
Zinfandel............	3	Sept. 19	23.1	0.70	3.45	33.0	480	Fair if grapes are clean

* These figures represent the relative intensity of color expressed on an arbitrary scale: the higher the figure the greater is the concentration of pigment.

† Davis and Manteca.

‡ Delano figures only

of the wine when intelligently practiced is not harmful and may even be desirable for certain types of wine. Although Federal Regulations No. 7 permit the use of "pure boiled or condensed grape must or pure crystallized cane or beet sugar or pure dextrose sugar, at the time of, or after fermentation,"[55] the sugar must not be in excess of 11 per cent of the weight of the wine. This restriction on amount of sweetening does not apply to grape products. California regulations prohibit the use of any sweetening agent other than grape concentrate. Sweetening agents, if any are used, may be added only prior to fortification, but see page 136.

[55] United States Bureau of Internal Revenue. Regulations No. 7, relative to the production, fortification, tax payment, etc., of wine. 188 p. (See especially p. 39 and 91.) United States Government Printing Office, Washington, D. C. 1937.

Period of Fermentation.—The period of fermentation for most sweet dessert wines, whether white or red, is usually short; hence the musts are fermented on the skins save where very light color is desired. Where light color is desired or for sherries, the crushed grapes are allowed to stand only until the cap forms and rises to the surface, and the free-run must is drawn off to be fermented separately. Fermentation on the skin yields wines containing more of the fruity flavor of the berry and is necessary for color extraction in the case of ports. To dissolve flavor and color, time is required. Since the must is usually fortified soon after active fermentation sets in, there is only a restricted period during which the juice and skins are in contact. The lower the initial Balling degree of the must and the warmer the grapes, the shorter is this fermentation period. To extend the period of contact, the grapes should be crushed when as cold as possible, and 4 to 6 ounces of potassium metabisulfite (or its equivalent of sulfur dioxide) added per ton of grapes directly after crushing. Good contact between the free-run juice and the skins must be established, and the fermentation should be conducted with a submerged cap or the cap punched down *frequently* and well. The crushing should be conducted so as to completely crush all berries and break the skins, without, however, breaking the seeds. Special procedures to insure adequate color extraction from red-grape skins are often used in preparing port-type wines.

Control of Fermentation.—The same principles as are necessary for making dry table wines of quality apply to the production of good dessert wines. Selection of grapes as to kind, quality, and maturity, fermentation with the utmost care and cleanliness at cool temperatures and with selected strains of yeast, and proper care during aging is just as necessary for one type as for the other. "Wines of quality are made; they do not just happen," to quote Humboldt.[56] The prevailing highly competitive dessert-wine market unfortunately has resulted in placing greater stress on the more economic production of sound wines for the cheaper trade than on production of wines of quality. Both the sound ordinary dessert wines available at a comparatively low price and the festive wines are needed, but a better balance in the amount of the two types produced in this state is necessary.

Too little attention is paid to the conditions of fermentation of dessert wines, particularly to the fermenting temperature, which often becomes so high as to favor development of harmful bacteria. When grapes are crushed at high temperatures, the must may stick in fermentation owing to the rapid development of acetic acid bacteria, which quickly form sufficient acetic acid to check growth of yeast (see p. 143). At these high

[56] Humboldt, E. Wine making is an art. Chemical and Metallurgical Engineering 43:651–53. 1936.

temperatures (90–100° F), the chemical activity of the yeast is also altered, so that abnormal flavor develops.

To avoid undesirable effects of microörganisms, the grapes should be crushed at as low a temperature as possible and the must cooled as directed for table wines. (See Bulletin 639, p. 48–52.) Dessert-wine musts, however, need not be cooled to as low a temperature as those for table wines, fermentation temperatures below 85° F being satisfactory.

Use of Sulfur Dioxide.—Sulfur dioxide should also be used to help control the activity of undesirable microörganisms.[57] The amount of sulfur dioxide added should be the minimum necessary to inhibit bacterial growth. Usually 4 ounces of potassium metabisulfite per ton of grapes (2 ounces of liquid sulfur dioxide) is sufficient and the amount should not exceed 6 ounces. The must should not contain too much sulfur dioxide at the time of fortification as otherwise the resulting wine will have a bad flavor. In the case of muscatels, Cruess (cited in footnote 15, p. 00) recommends the addition of 100 parts per million of sulfur dioxide (7 ounces of potassium metabisulfite per ton) commercially, although as little as 50 parts per million (3 ounces of metabisulfite) prevented bacterial development in wines fermented experimentally at temperatures of 85 to 90° F.

The amount of sulfur dioxide necessary is greater the warmer the grapes and the higher their Balling degree. After early fall rains larger amounts may also be required. Lightly fermented musts tolerate less residual sulfur dioxide than more completely fermented ones. A small amount of residual sulfur dioxide is not harmful even in the distilling material, for it combines with the sugars and aldehydes present in the wine and improves its keeping quality. Excessive amounts in the distilling material, however, corrode the plates and interior walls of the still, yield unpleasant-smelling volatile sulfur derivatives (mercaptans), and result in fortifying brandies that do not blend well with the musts.

The extent to which the addition of 4 ounces of potassium metabisulfite per ton of grapes reduced the volatile acidity of Fresno sweet wines during the vintage season of 1936 is shown in table 20. The average (calculated as the mode) for the sulfited wines was 0.0349, that for unsulfited 0.0399. There were too few samples of the latter, however, to obtain a good comparison. Cool fermentation and the use of sound grapes combined to yield the favorable results reported for the unsulfited wines. These results indicate that under sanitary conditions sulfur dioxide need not be used regularly in the fermentation of musts for dessert wines.

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[57] Cruess, W. V. Observations of '36 season on volatile acid formation in Muscat fermentation. Fruit Products Journal 16:198–200, 215, 219. 1937.

Theron, C. J., and C. J. G. Niehaus. Wine making. Union of South Africa Dept. of Agr. Bul. 191:1–98. (See p. 58 and 61.) 1938.

During the vintage season of 1934 and 1935, much higher volatile acidities were found in the freshly fortified, unsulfited wines.

Use of Pure Yeasts.—Pure wine yeast is not widely used at present in fermenting dessert wine musts. The grapes for these wines are picked at a stage of maturity when the numbers of yeast cells present on the grapes are high and no difficulty is experienced in starting the must to ferment. A few wineries use starters to obtain faster fermentations so that the fermenters may be reused more frequently; or to obtain wines

TABLE 20

Influence of Sulfur Dioxide on the Volatile-Acid Content of the Finished Wine in 12 Fresno Wineries

Treatment and winery no.	Samples	Volatile-acid content of wine	
		Range	Average
	number	*per cent*	*per cent*
With metabisulfite*			
No. 1	9	0.009–0.048	0.032
No. 2	4	.021– .033	.027
No. 3	9	.004– .066	.032
No. 4	9	.019– .066	.045
No. 5	17	.013– .048	.031
No. 6	5	.020– .041	.033
No. 7	12	.020– .090	.041
No. 8	6	.023– .040	.034
No. 9	6	.030– .068	.047
Total	77	.004– .090	.035 (mode)
Without metabisulfite:			
No. 10	4	.016– .031	.026
No. 11	7	.024– .059	.041
No. 12	5	.039– .108	.073
Total	16	0.016–0.108	0.040 (mode)

* 4 ounces of potassium metabisulfite per ton of grapes used.

that clear better owing to the use of pure wine yeasts that agglomerate or clump together and settle out as a granular deposit rather than yield a finely dispersed cloud of yeast cells. The use of strains of yeast selected so as to develop the most flavor from the available variety of grape is still in its infancy. The use of such selected strains of yeast might help to improve the flavor of the available dessert wines.[58]

Fermentation By-Products.—The short fermentation period, the conversion of only a part of the sugar initially present, and the dilution during fortification combine to reduce the concentration of the by-products of alcoholic fermentation in dessert wines. The partially fermented musts are lower in volatile acid, fixed acid, and glycerin content than are the completely fermented wines. A significant change also

[58] Joslyn, M. A. Biological control of fermentation. Wines and Vines 19(4): 16–17. 1938.

occurs in the type of reducing sugars present. The levulose-dextrose ratio increases from slightly under 1 to much more than 1, and this increase is reflected in the change in degree and even sign of the optical rotation of the wine (which becomes more levorotatory; see p. 16).

By-products of fermentation which accumulate at a faster rate in the early stages of fermentation influence the flavor of dessert wines much more than those which accumulate in the later stages of fermentation. Yeast strains forming aromatic flavorful constituents in the early stages of fermentation will therefore be most useful.

Influence of Acidity.—It is commonly believed that the acid content of the musts for dessert wines should be low since a high acid content does not yield a well-balanced young wine. If a low-acid wine is matured for several years, however, it becomes flat to the palate and lacks fruitiness. High acidity is also useful in suppressing the growth of harmful bacteria. Theron and Niehaus (cited in footnote 57, p. 42) recommend an acidity of 0.60 per cent as tartaric for dessert wines. Fornachon[59] recommends the addition of tartaric acid to must to insure that the primary fermentation will take place under conditions favorable for the optimum flavor production with the minimum of autolysis of yeast cells. A wine made from a properly balanced must is clearer, more stable, and more resistant to bacterial attack. Cruess (cited in footnote 15, p. 14) found that the addition of citric acid produced muscat wines of lower volatile acidity.

Fermentation.—As a rule the crushed grapes are fermented on the skins for 2 to 3 days, the free-run wine is then drawn off (approximately 140 gallons per ton of grapes). The pomace is not pressed to obtain wine because such press wine would be too harsh in flavor, and of poor quality. The remaining pomace is covered with water and allowed to ferment dry with occasional stirring; this requires another 3 days, and the low-alcohol wine produced is used exclusively for distilling material. The free-run pomace wine is drawn off and the pomace washed or pressed (see p. 56).

Distillery Capacity.—The capacity of the distillery determines the quantity of wine to be made, for there should be an ample supply of fortifying brandy on hand to fortify at the right time; or, if a sufficient amount cannot be produced, arrangements for the purchase of the needed amounts should be made. Twight[60] considers an adequate supply of fortifying brandy to be the most important factor in the production of good dessert wines and in the economical operation of the winery. He

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[59] Fornachon, J. C. M. Bacterial fermentation in fortified wines. 19 p. Australian Wine Board Publication on Wine Investigations. 1938. (Mimeo.)

[60] Twight, Edmund H. Sweet wine making in California. Part II. California Grape Grower **15**(11):4–5, 7. 1934.

estimates that a winery having a distillery with a capacity of 2,000 gallons of 90 per cent (180° proof) fortifying brandy a day should not handle over 100 tons of wine grapes a day if maximum production and quality is desired. If too large a tonnage is crushed, there will be insufficient brandy to stop the fermentation at the desired Balling and the wines will be below standard in sugar content. There is also danger that the wine will be allowed to ferment until it gets "stuck," and when such wine is fortified it yields a product of poorer aroma, flavor, and keeping quality.

Use of the Hydrometer.—As in the making of dry table wines, the course of fermentation is followed by the Balling or the Brix hydrometer and a long-stem or indicating thermometer. After the grapes are crushed and before fermentation sets in, the approximate sugar content of a representative sample of the must is determined by the Balling hydrometer. In the absence of alcohol, the Balling degree is higher than the actual sugar content owing to the presence of acids, salts, and other soluble nonsugar constituents. The Balling degree often rises shortly after crushing, especially if raisins are present, owing to extraction of sugar from the nonjuicy, high-sugar grapes. With the onset of full fermentation, the Balling degree drops, not only because of decrease in sugar content but also because of the formation of alcohol, which lowers the specific gravity of the solution.

In a partially or completely fermented must, the Balling degree is lower than the actual sugar content. The extent of such reduction varies with the relative alcohol and sugar content;[61] at a given sugar concentration, the higher the alcohol content the lower will be the indication of the Balling hydrometer. In spite of this discrepancy, the Balling hydrometer is commonly used as an indication of the extent of fermentation in both dessert-wine and table-wine making.

The Balling degree of a wine or must may be corrected for the effect of alcohol by the procedure suggested in paragraph 329 of Regulations No. 7 (cited in footnote 55, p. 40). This is based on the assumption that the effect of alcohol in decreasing the specific gravity of water solution is independent of other solutes, that is, that the specific gravity of a solution of sugar and alcohol is lowered by alcohol to the same extent as is that of water alone. The specific gravity of the solution then varies from that of water by the difference between the increase caused by the presence of sugar and the decrease caused by the presence of alcohol. It is assumed that not only are the effects of the individual constituents additive, but also that volume changes during solution are negligible. The relation used is as follows:

[61] Joslyn, M. A. Approximate alcohol tables for wine. California Grape Grower 15(11):12–13. 1934.

Specific gravity of dealcoholized wine=specific gravity of wine – specific gravity of an alcohol solution containing the same percentage of alcohol as the wine + 1.

To use this relation, it is necessary to have tables showing the specific gravity of solutions of alcohol and of cane sugar at various concentrations. (See tables 33 and 35, p. 154 and 158, in this publication, and tables 4 and 5 in Regulations No. 7.) Three examples will illustrate this calculation.

Example 1. Suppose that a wine tests 6° Balling at 60° F and contains 12 per cent alcohol. The specific gravity of such a wine is 1.02320; the specific gravity of the alcohol solution of equivalent alcoholic strength is 0.98430. Subtracting the latter from the former leaves 0.03890, and adding 1 gives 1.03890, the specific gravity of dealcoholized wine. This corresponds to 9.9° Balling.

Example 2. Suppose that a wine tests 6° Balling at 60° F and contains 21 per cent alcohol. The specific gravity of such a wine is 1.02320; the specific gravity of the alcohol solution of equivalent alcoholic strength is 0.97496. The specific gravity of dealcoholized wine is then: 1.02320 – 0.97496 + 1, or 1.04824, which corresponds to 12.2° Balling.

Example 3. A partially fermented must for port tests 14.1° Balling and contains 6.4 per cent alcohol before fortification. The specific gravity of the dealcoholized wine would then be 1.0560 – 0.99098 + 1, or 1.06502, which corresponds to 16.3° Balling.

FORTIFICATION

Fortification is the process of raising the alcoholic content of a partially fermented wine or of an unfermented must by addition of fortifying brandy to a concentration sufficiently high to check the fermentation and to prevent refermentation.

Legal Restrictions.—The quantity and kind of brandy used in fortifying wine is restricted by federal and state agencies. For the purpose of taxation, three classifications of wines are established by United States Internal Revenue law: wines containing not more than 14 per cent alcohol by volume, wines containing more than 14 per cent and not exceeding 21 per cent, and wines containing more than 21 per cent and not exceeding 24 per cent. Under the Definitions and Standards for Wines of the California Department of Public Health, the commercially recognized, named types of dessert and appetizer wines are required to have a range in alcohol content of 19.5 to 21.0 per cent by volume (±0.5). Altar wines produced for ecclesiastical purposes may contain as little as 18 per cent of alcohol. A few states have slightly different restrictions on the maximum and minimum alcohol contents of dessert

wines and, if shipments into such states are contemplated, details should be obtained directly from the proper state authorities. According to Theron and Niehaus (cited in footnote 57, p. 42), South African law requires fortification to at least 17 per cent of alcohol.

Amount of Alcohol Required.—The concentration of alcohol necessary to prevent the fermentation of fortified sweet wines depends on the strain, physiological condition, and numbers of yeast cells present; the composition of the wine, particularly its acidity, pH value, and nitrogen content; and temperature and other external environmental factors.

Yeasts are less sensitive to alcohol than many bacteria and most other fungi; still most yeast fermentations are strongly retarded at 5 to 6 per cent alcohol and practically cease at 14 per cent. Alcohol-tolerant wine yeasts, however, are known, particularly the Brazilian Logos yeast, and these produce up to 18 per cent alcohol by direct fermentation of must containing sufficient sugar (30 per cent or over). Even the common wine yeasts can produce, under special conditions, wines of 20 per cent alcohol content.[62] The strongly respiratory aerobic yeasts such as the apiculate yeasts and Saaz-type beer yeasts, on the other hand, are inhibited at alcoholic concentrations of only 4 to 6 per cent.

Theron and Niehaus recommend that wine be fortified to at least 17 per cent of alcohol by volume to prevent fermentation. This concentration may not be high enough to check the fermentation, particularly with active wine yeast, which may grow in wines up to 18 to 20 per cent alcohol.[63] Ventre[64] points out that the abrupt addition of 15 per cent alcohol to a medium which is not in fermentation inhibits subsequent development of yeast; but when the addition is made to a medium in active fermentation the process is at first arrested and then continues at a slower rate until the maximum quantity of alcohol tolerated by the particular strains of wine yeast, approximately 16–18 per cent, is formed. Euler and Lindner[65] point out that the sensitivity of yeast to alcohol

[62] Cruess, W. V., E. M. Brown, and F. Flossfeder. Sweet wines of high alcohol content without fortification. Journal of Industrial and Engineering Chemistry 8:1124–26. 1916.

Hohl, Leonora, and W. V. Cruess. Effect of temperature, variety of juice, and method of increasing sugar content on maximum alcohol production by *Saccharomyces ellipsoideus*. Food Research 1:405–11. 1936.

Hohl, Leonora. Further observations on production of alcohol by *Saccharomyces ellipsoideus* in syruped fermentations. Food Research 3:453–65. 1938.

[63] Kohl, F. G. Die Hefepilze, 343 p. (See especially p. 150 and 152–53.) Verlag von Quelle und Meyer, Leipzig, Germany. 1908.

[64] Ventre, Jules, Traité de vinification pratique et rationnelle. vol. 1. Le raisin. Les vinifications. 490 p. (See especially p. 108–9.) Librairie Coulet, Montpellier, France. 1930.

[65] Euler, Hans, and Paul Lindner. Chemie der Hefe und der alkoholischen Gärung. 350 p. (See p. 283–84.) Akademische Verlagsgesellschaft m.b.h., Leipzig, Germany. 1915.

increases with increase in sugar content of the medium. Hartelius[66] indicates that acids as well as alcohol inhibit growth and fermentation. Both Hartelius and Rahn[67] indicate that the gradual retardation and ultimate cessation of the rate of fermentation before all the fermentable substrate is used up is due to the toxic action of fermentation products, particularly of the alcohol. Growth of yeast ceases at a lower concentration of alcohol than does the fermentation produced by the yeast, although the rate of fermentation gradually decreases as the concentration of alcohol, whether added or formed, increases.

The danger of spoilage of sweet dessert wines by growth of lactic acid bacteria, which grow in wines of low acidity even up to 20 per cent alcohol, has prevented the gradual raising of the alcoholic content by the periodic addition of small quantities of fortifying brandy, as is practiced in European dessert-wine production. Gradual fortification is possible there, because of the higher acidity of these wines and because the smaller cooperage used there facilitates handling the wines at lower temperatures; although cases of spoilage of fortified wine are not uncommon in these countries. When fortifying brandy is added in installments so that fermentation continues at a diminished rate for a week or over, the brandy blends better with the sweet wine. The product is mellower and softer than one of the same alcoholic content obtained by adding all the alcohol in one application at the end of the process. However, autolysis of yeast occurring during the retarded fermentation obtained by gradual fortification may contribute to the spoilage by lactic acid bacteria, according to Fornachon (cited in footnote 59, p. 44). Furthermore, Hohl and Cruess experienced difficulty in preventing "mousiness" of wines of high alcoholic content obtained by siruped fermentation : that is, where grape concentrate was periodically added during the fermentation. Gradual fortification is also more expensive than is a single, abrupt fortification.

The California sweet, dessert wines are fortified to an alcoholic content of 20 to 21 per cent by volume; occasionally lots may be fortified to as low as 19 per cent or as high as 24 per cent for blending purposes. The standard wines are marketed at 20 per cent alcohol, California port testing 6° Balling, muscatel and Angelica 7° Balling or over, and sherry 1° to −3° Balling. The higher the alcohol content obtained by the fortification, the more costly is the process, and the longer the time required to age. Wines to be consumed fairly young are more pleasing to taste at 18 per cent than at 21 per cent alcohol.

[66] Hartelius, V. The growth of yeast in synthetic media and the factors produced by yeast which limit this growth. Carlsberg Laboratoire Comptes-Rendus des Travaux 20(7):1–43. 1934.

[67] Rahn, Otto. The decreasing rate of fermentation. Journal of Bacteriology 18:207–26. 1929.

The quality of the fortifying brandy has a great effect on the flavor of the dessert wines. Only sound clean brandy free from objectionable flavors should be used and the quantity added must be at a minimum to reduce dilution of the wine flavors. Fruity-flavored brandies obtained from the varieties of grapes used in making the particular wine are pre-

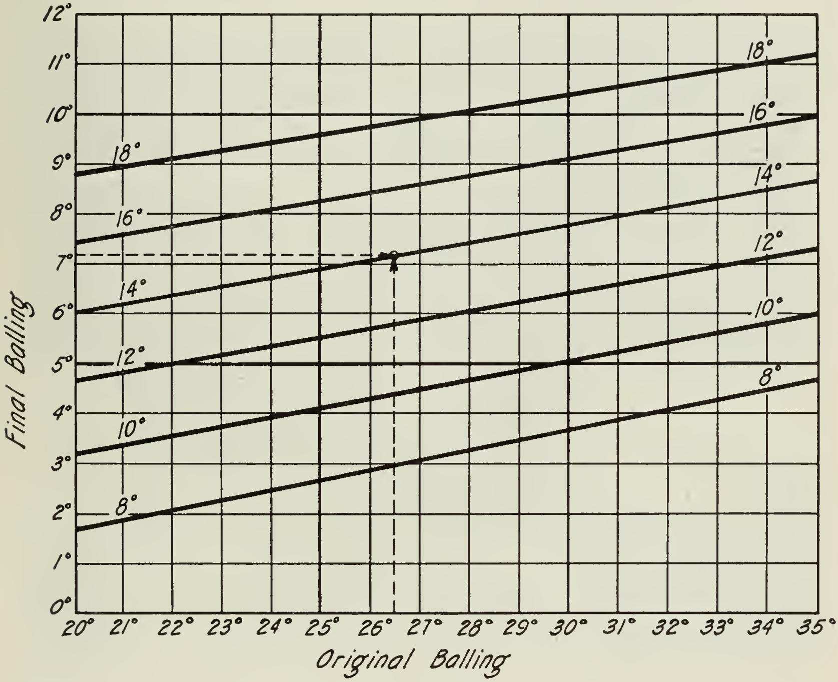


Fig. 1.—Chart for approximately determining the final Balling, or the time to fortify to produce a given Balling, when musts of from 20°–35° Balling are fortified at different stages of fermentation to 20.5 per cent alcohol. The figures at the left represent final Balling, those at the bottom original Balling, and the diagonal lines are Balling at the time of fortification.

In the example marked on the figure: if the original must were 26.5° and a final Balling of 7.2° were desired, the fortification would have to take place at 14°.

Under winery conditions this chart will give only approximate results because of the fermentation taking place during and immediately after fortification.

Intermediate fortification Ballings can be obtained by interpolation.

ferred for the fortification of that wine. Neutral grape spirits are more acceptable, in general, than unsound grape-flavored ones. Under federal law only brandy from fermented grape products may be used in wine production. For further discussion of fortifying brandy see pages 57 and 78 and Bulletin 652.

Procedure.—It is difficult to check the fermentation of a must at just the degree to obtain a particular Balling degree after fortification owing to variation in the initial sugar content of the must and the drop in Balling degree during the time elapsed between drawing off from the

fermenter into the fortifying tank and fortification. Hence most wineries fortify several lots of the same type of wine at various sugar contents and to various alcoholic contents and then blend to obtain the desired composition. If the initial sugar content is known, it is possible to calculate the Balling degree at which the must should be fortified to a given alcoholic content (20.5 per cent in fig. 1) to yield a wine of a desired

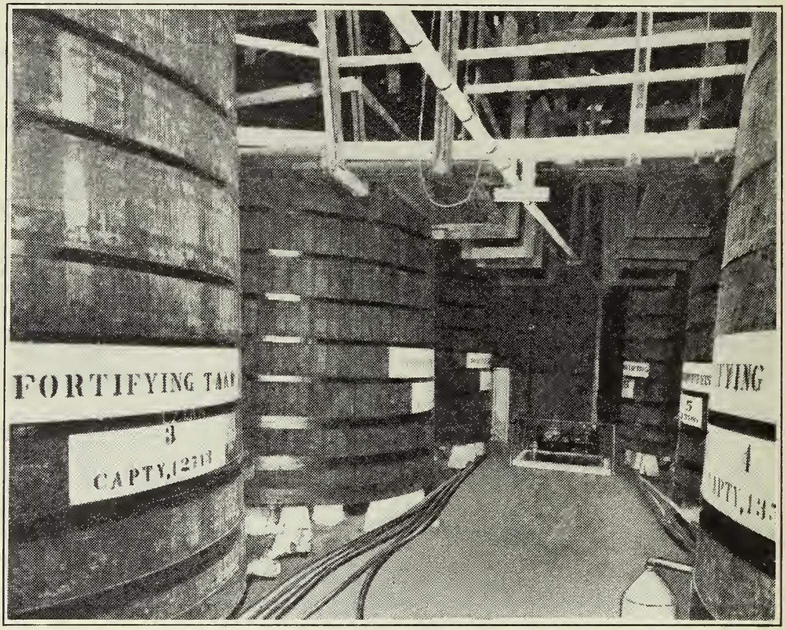


Fig. 2.—Fortifying room with redwood tanks. Note the labeling of the tanks with the capacity, purpose, and number in order to conform to federal regulations. (Photograph by courtesy of the Wine Institute.)

Balling degree. Typical changes in the Balling of various musts which take place during fortification are presented graphically in figure 1.

The wine to be fortified is pumped from the fermenters at a Balling reading 2° to 4° higher than is desired at the time of fortification. This allows for the decrease in sugar content that occurs during the transfer to the fortifying tank and as a result of fermentation that continues during fortification and for a short time thereafter, particularly in actively fermenting musts. The fortifying brandy necessary is added under the supervision of a United States gauger in the manner prescribed in Regulations No. 7 (cited in footnote 55, p. 40). The fortification is carried out in a special room, called the "fortifying room," which is equipped with closed fortifying tanks of the necessary capacity (usually two such tanks holding from 10,000 to 50,000 gallons), closed storage tanks for brandy, and a weighing tank for weighing out the

quantities of fortifying brandy received and used for fortification (fig. 2). A well-lighted, heated, and ventilated office must be provided within the fortifying room for the use of the government officers assigned to supervise fortification.

When the wine to be fortified is pumped over into one of the fortifying tanks, whose capacity to the nearest hundredth of a gallon per inch of depth is indicated on a table attached to the tank, it should be thoroughly mixed; this is usually done with compressed air.[68] The gauger then withdraws a sample, determines its alcohol content by the use of a suitable

TABLE 21

PER CENT CONTRACTION OF WATER-ALCOHOL-SUGAR MIXTURES WHEN FORTIFIED TO 20.5 PER CENT ALCOHOL WITH 184° PROOF FORTIFYING BRANDY

Original per cent alcohol	Per cent contraction				
	With 0 per cent dextrose†	With 5 per cent dextrose	With 10 per cent dextrose	With 15 per cent dextrose	With 20 per cent dextrose
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
0	1.347	1.48	1.39	1.41	1.45
5	1.258	1.30	1.24?	1.37	1.37
10	0.908	0.87	0.88	0.78	0.80
15	0.595	0.628	0.655	0.754?	0.661

* The contractions were obtained by adding a measured volume of high-proof to a measured volume of the alcohol-water or alcohol-water-sugar mixture. The volume of the fortified mixture was obtained by dividing the weight of 100 cc of water-alcohol-sugar mixture plus the fortifying brandy by the weight of 100 cc of the final fortified solution (by the specific gravity, in other words). The theoretical volume of the mixture is known (by addition of volumes) and the difference between it and the actual volume represents the contraction. The per cent contraction was calculated as per cent of the theoretical volume.

† International Critical Tables gives the contraction as 1.50 per cent for fortification from 0 per cent alcohol to 20.5 per cent alcohol at 0 per cent dextrose when 100 per cent alcohol is used to fortify with.

ebullioscope, ascertains that the wine is eligible for fortification, and allows the wine maker to add enough of the fortifying brandy, already gauged for the fortification, to the wine to arrest fermentation. The gauger then completes the tests and determines the amount of fortifying brandy necessary to fortify the wine to the desired alcoholic strength.

Methods of Calculation.—The amount of fortifying brandy to be added depends on: (1) the original alcoholic strength of the wine; (2) the alcoholic strength of the fortifying brandy used (in per cent by volume; this is always one half of the proof strength in United States usage); and (3) the resulting alcoholic strength of the mixture. The higher the alcoholic strength of the fortifying brandy used, and the higher the alcoholic content of the wine to be fortified, the smaller will be the volume of fortifying brandy required to produce any desired alcoholic strength; but in no case should the alcoholic content of the resulting fortified wine exceed 24 per cent by volume. The quantity in wine gallons, X, of fortifying brandy containing B per cent alcohol by

[68] This air must not be contaminated with oil or particles of rust. Usually oil traps and filters must be installed in the air lines.

volume, required to fortify V gallons of wine of A per cent alcohol to an alcohol content of C per cent by volume may be calculated by the formula $X=\frac{V\,(C-A)}{B-C}$. This formula, given as official in Regulations No. 7, disregards the contraction due to admixture of alcohol and wine. This contraction amounts to from ½ to 1½ per cent, according to the sugar and alcohol content. (See table 21.)

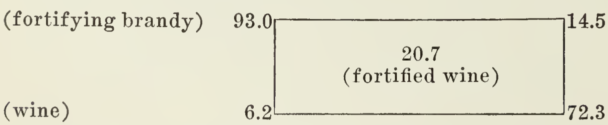
As an example, we shall calculate the quantity of 186-proof fortifying brandy necessary to fortify 15,035 gallons of port stock having an alcoholic content of 6.2 per cent by volume to 20.7 per cent.

Here $V=15{,}035$, the number of wine gallons to be fortified
$C=20.7$, the desired percentage of alcohol by volume in the wine after fortification
$A=6.2$, the percentage of alcohol in wine to be fortified
$B=93$, the percentage of alcohol in the fortifying brandy to be used in fortifying the wine

$$X=\frac{15{,}035\ (20.7-6.2)}{93-20.7}=3{,}015.32 \text{ wine gallons.}$$

The answer is purposely given to the nearest hundredth of a gallon because this is actually required by law, although the figures to the right of the decimal point are of little significance.

This algebraic formula may be graphically pictured by the use of the Pearson square as follows: Draw a rectangle and at the upper left-hand corner place the alcoholic content of the fortifying brandy (93.0); at the lower left-hand corner place the alcoholic content of the wine to be fortified (6.2); and in the center place the alcoholic content of the desired wine (20.7). Then subtract the center figure from the higher (upper left-hand) figure and place the result (93.0–20.7, or 72.3) in the diagonally opposite (lower right-hand) corner. Subtract the lower left-hand figure from the center value and place the result in the diagonally opposite (upper right-hand) corner. The results of these subtractions at the right then yield the ratio in which the wine and fortifying brandy are to be mixed to yield a fortified wine of the desired alcoholic strength. Thus by reference to the diagram below, 14.5 parts of fortifying brandy of 93.0 per cent alcohol must be mixed with every 72.3 parts of wine of 6.2 per cent alcohol to yield 14.5 + 72.3, or 86.8 parts of fortified wine of 20.7 per cent alcohol.



To calculate the quantity of fortifying brandy required to fortify any

given volume of the wine, divide this volume by 72.3 and multiply the result by 14.5.

The quantity of fortifying brandy necessary to fortify a given quantity of wine to a certain alcoholic content may be calculated from table IX of Regulations No. 7, which gives the number of wine gallons of fortifying brandy containing various concentrations of alcohol to be added to 100 wine gallons of wine containing various percentages of

TABLE 22

Number of Gallons of Brandy to be Added to 100 Gallons of Wine Containing Various Percentages of Alcohol to Produce a Fortified Wine Containing 21 Per cent Alcohol*

Alcohol in initial wine	Per cent of alcohol in brandy									
	82	84	86	88	90	91	92	93	94	95
volume per cent	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*	*gallons*
0	34.43	33.33	32.31	31.34	30.43	30.00	29.58	29.17	28.77	28.38
1	32.79	31.75	30.77	29.85	28.98	28.57	28.17	27.78	27.40	27.03
2	31.15	30.16	29.23	28.36	27 54	27.14	26.76	26.39	26.03	25.68
3	29.51	28.57	27.70	26.86	26.10	25.72	25.36	25.00	24.66	24.33
4	27.87	26.98	26.16	25.37	24.64	24.29	23.95	23.61	23.29	22.98
5	26.23	25.39	24.62	23.88	23.19	22.86	22.54	22.22	21.92	21.63
6	24.59	23.81	23.08	22.39	21.74	21.43	21.13	20.83	20.55	20.28
7	22.95	22.22	21.54	20.89	20.30	20.00	19.72	19.44	19.17	18.92
8	21.31	20.63	20.00	19.40	18.85	18.57	18.31	18.05	17.80	17.57
9	19.67	19.04	18.46	17.91	17.40	17.14	16.90	16.66	16.43	16.21
10	18.03	17.46	16.92	16.41	15.94	15.71	15.49	15.27	15.06	14.86
11	16.39	15.87	15.39	14.93	14.49	14.28	14.08	13.88	13.69	13.51
12	14.75	14.28	13.84	13.43	13.04	12.85	12.67	12.50	12.32	12.16
13	13.11	12.69	12.30	11.94	11.59	11.42	11.26	11.11	10.95	10.81
14	11.47	11.11	10.76	10.44	10.14	10.00	9.85	9.72	9.59	9.45
15	9.83	9.52	9.23	8.95	8.69	8.57	8.45	8.33	8.21	8.10

* Data do not consider the influence of contraction on the final volume (see table 21, p. 51).

Sources of data:

United States Bureau of Internal Revenue, Regulations No. 7 relative to the production, fortification, and tax payment, etc., of wine. 188 p. (See table IX.) United States Government Printing Office, Washington, D. C. 1937.

Data below 9 per cent alchol calculated from the formula $A/B = \frac{m-b}{a-m}$ where m is 21 per cent, b is the per cent alcohol in the original wine, a is the per cent alcohol in the brandy, and B is 100 gallons.

alcohol to produce a resulting fortified wine of various alcoholic contents. Table 22, calculated in part from table IX of the Regulations, illustrates these values for several conditions.

Some typical fortification records are given in table 23. The range in composition of musts and wines before and after fortification in pre-Prohibition and post-Prohibition wineries is given in table 24. Careful and experienced wine makers are able to eliminate extreme variations and thus improve the quality of their product.

Since the quantity of fortifying brandy to be added must be gauged accurately, it is usually weighed, the gauger determining the weight

equivalent to the calculated volume of the fortifying brandy by reference to the tables given in the Gauging Manual.[69]

After Fortification.—The fortifying brandy and wine must be thoroughly mixed, otherwise the spirits, which are of lower specific gravity, will float on top, and the insufficiently fortified must will continue to ferment. Mixing may be done by stirring with an agitator, by pumping

TABLE 23

TYPICAL FORTIFICATION RECORDS FROM A CALIFORNIA WINERY

Type and record no.	At the time of fortification			Brandy weighed out	After fortification		
	Amount	Balling	Alcohol		Amount	Balling	Alcohol
	gallons	*degrees*	*volume per cent*	*gallons*	*gallons*	*degrees*	*per cent*
Sherry:							
No. 1	24,237	−1.5	13.9	2,917.4	27,154	−4.1	20.8
No. 2	22,379	−1.3	13.0	2,640.8	25,014	−4.0	20.6
No. 3	16,267	1.8	12.6	1,923.8	18,109	−2.2	20.9
No. 4	2,849	4.6	10.6	399.6	3,234	−1.4	21.0
Port:							
No. 1	22,436	14.7	6.3	4,482.0	26,774	7.8	20.5
No. 2	17,180	13.1	6.2	3,367.7	20,403	5.9	20.5
No. 3	15,084	15.8	4.9	3,299.8	18,308	7.8	20.9
No. 4	12,783	14.9	4.5	2,780.2	14,427	6.7	21.5
Muscat:							
No. 1	20,676	15.8	5.2	4,564.8	25,177	8.1	20.7
No. 2	18,612	16.2	4.7	4,135.1	22,569	7.8	20.8
No. 3	21,340	15.0	5.7	4,457.6	25,627	7.4	20.7
No. 4	16,694	16.7	5.1	3,311.1	19,909	9.4	20.5
Angelica:							
No. 1	15,684	17.8	1.2	3,996.0	19,602	9.0	20.8
No. 2	15,639	17.1	1.8	3,941.3	19,502	8.3	21.0
No. 3	15,314	16.2	2.4	3,367.2	18,905	7.7	21.0
No. 4	15,230	13.2	3.9	3,551.2	18,706	5.6	21.1

over, or by thorough aeration with compressed air. This aeration removes the excess of carbon dioxide in the wine and also aids subsequent maturation. During this mixing, heat is evolved as the alcohol goes into solution, and because of this, the volume of the wine is greater than that of the sum of the volumes of fortifying brandy and must used. When the wine is cooled, however, the resulting volume is somewhat less, owing to contraction that occurs when alcohol and water are mixed.

After mixing, the gauger samples the fortified wine, tests it to see if the actual final alcohol content corresponds to the estimated, and sets aside a sealed 1-pint sample. Two such samples, representing forti-

[69] United States Bureau of Internal Revenue. Gauging manual embracing instructions and tables for determining the quantity of distilled spirits by proof and weight. 579 p. United States Government Printing Office, Washington, D. C. 1938.

TABLE 24

ALCOHOL AND BALLING BEFORE AND AFTER FORTIFICATION FOR VARIOUS TYPES OF WINE IN PRE- AND POST-PROHIBITION WINERIES

Type of wine, location of winery, and years	Samples	Initial alcohol content		Initial Balling		Final Balling		Final alcohol content	
		Range	Average	Range	Average	Range	Average	Range	Average
	number	*volume per cent*	*volume per cent*	*degrees*	*degrees*	*degrees*	*degrees*	*volume per cent*	*volume per cent*
Port:									
Sanger, 1906–1913	105	4.9–11.5	8.4	6.7–20.7	13.9	—	—	16.5–23.6	20.6
Lodi, 1938–1940	47	0.5–12.8	5.2	2.6–23.3	14.7	−1.0–11.6	6.6	18.9–23.8	21.0
Fresno, 1938–1940	18	3.6– 6.5	5.7	12.3–15.6	13.6	4.8– 7.8	6.4	20.1–20.8	20.4
Sherry:									
Sanger, 1906–1913	27	6.2–13.4	9.1	4.0–20.0	11.5	—	—	18.3–23.6	21.2
Lodi, 1938–1940	53	9.8–15.5	12.5	– ?– 4.6	—	−4.8– −1.4*	−3.3*	20.1–23.9	20.8
Fresno, 1938–1940	32	10.8–14.2	12.2	−1.7– 3.4	1.1	−4.3– −0.5	−2.3	20.4–21.2	20.7
Muscat:									
Sanger, 1906–1913	41	6.0–11.1	8.0	8.1–16.9	12.8	—	—	17.6–23.1	20.6
Fresno, 1938–1940	43	12.6–16.7	14.2	4.7– 8.9	7.0	6.1– 9.4	7.4	20.1–20.9	20.6
Angelica:									
Lodi, 1938–1940	2	0.8– 4.5	2.6	17.0–19.0	18.0	8.5– 9.2	8.8	20.8–21.0	20.9
Fresno, 1938–1940	3	2.5– 5.7	4.5	15.0–17.6	15.9	7.4– 8.1	7.7	20.5–20.8	20.7
White port:									
Lodi, 1938–1940	21	0.5– 7.5	3.3	8.0–22.5	15.3	2.0–12.9	7.0	19.5–21.3	20.6
Fresno, 1938–1940	5	4.7–11.5	6.9	1.8–13.1	10.5	−2.3– 5.7	3.7	20.4–21.2	20.6

* Average and range on 22 samples only.

fications at different periods of the month, are forwarded to the nearest laboratory of the Alcohol Tax Unit of the Bureau of Internal Revenue (Federal Building, Civic Center, San Francisco) for testing. The alcoholic content as determined later is usually somewhat lower than that obtained by the gauger because of inaccuracies in the rapid method used by the gauger. The wine after fortification is released for transfer to the storage cellar.

There are many variations in the details of fortification: the type and size of fortifying tank; the method of adding the fortifying brandy, whether first or last; the method of mixing; and the period of time the wine is allowed to remain in the fortifiers. Several of the pre-Prohibition wine makers preferred to run the fortifying brandy into the tank first and then add the wine and allow the mixing to occur naturally by diffusion. Their wines were also frequently stored for longer periods of time in the fortifying tanks before transfer to the storage cellar.

Settling.—During fortification there is a rapid flocculation of yeast, proteins, and gums; and it is preferable to allow the fortified wine to settle in the fortifying tanks for at least 24 hours before it is pumped out, to allow these insoluble matters to deposit. This period is sufficient to bring to a close the fermentation, which continues for a time even in the presence of the high concentrations of alcohol. According to most modern wine makers, the sooner the newly fortified wine is separated from the crude lees, after the lees settle, the better is its flavor and the more rapidly it mellows during storage. Where the fortifying room is small or is in constant use, the wine is pumped out of the fortification tanks into storage immediately, and is given its first racking in the cellar as soon as possible after settling.

Production of Distilling Material.—The distilling material, from which the fortifying brandy is obtained, is usually prepared from low-alcohol wine made from the pomace left in the fermenters after the free-run wine has been drawn off for fortification. Water is added to the fermenter in quantity sufficient to cover the pomace, and the pomace is well mixed with it by thorough punching or pumping over. The mixture is allowed to ferment out dry.

To obtain the maximum yield of alcohol, it is essential that the sugar in the pomace be completely fermented out. When the fermentation is completed, the free-run pomace wine is drawn off and the residual alcohol in the pomace is removed as completely as practicable. This may be done in several ways. In one procedure the pomace is pressed out in a continuous expeller press and then washed in a counter-current type of washer (diffusion battery) to remove the residual alcohol, which may run as high as 5 per cent. In another, the pomace, after the first refer-

mentation, is mixed again with water, allowed to ferment for an additional 24 hours, and then pressed. The extent to which alcohol recovery may be practiced is determined by the tanks available for pomace washing and by the time and labor available for this purpose. In some cases the fermented pomace is ground or otherwise disintegrated, is allowed to ferment for about 24 hours more, and is finally run directly into a pomace still. The seeds are crushed by this procedure.

The fermentation of the distilling material should be carefully controlled so that it will not be subjected to bacterial decomposition by either the acetic acid or lactic acid bacteria. Sour or "mousy" distilling material yields a fortifying brandy of objectionable flavor that should not be used in making dessert wines of high quality. Small quantities of sulfur dioxide may be used in controlling bacterial development, but it is best not to use sulfur dioxide or to use it only for sprinkling over exposed pomace. Temperature control and fermenting with submerged pomace are preferable to the use of sulfur dioxide for obtaining sound distilling material.

It is generally necessary to crush additional grapes to produce the brandy needed for fortification, and cheaper table grapes or packinghouse culls are used for that purpose. These should be sound and, to expedite fermentation, they should be mixed with an equal volume of water. The lower the initial sugar content, the more rapidly will the must ferment out dry and the less will be the chances for contamination because of reduction in time of contact. Prolonged fermentation of distilling material is uneconomical and undesirable for other reasons.

The distilling material is adjusted to an alcoholic content of about 6 to 8 per cent, according to the operating characteristics of the still, and the alcohol is distilled off in a continuous single-column still at a proof varying with the type of distilling material and the requirements of the wine maker.

Quality of Fortifying Brandy.—The poorer the quality of the distilling material available, the higher should be the proof of the fortifying brandy obtained in order to avoid contamination with objectionable volatile acids, higher alcohols, aldehydes, and esters. The highest proof obtainable by direct distillation is approximately 190° (at 68° F). Such a spirit is very neutral in taste and is free from all congenerics, such as aldehydes, esters, and fusel oils. If the distilling material is sweet-smelling and free from objectionable flavors, a fortifying brandy of 175° to 180° may be made. This will have a higher concentration of congenerics. Fortifying brandy of alcoholic concentration lower than 175° proof is not ordinarily used because it may dilute the wine too much and give a product of thin body, particularly when the original

wine is low in nonsugar solids. Aldehydes and fusel oils are objectionable in a fortifying brandy, particularly when present in high concentrations, because such a brandy will not quickly blend well with the wine. Some wine makers, however, prefer fortifying brandy of 175° to that of 180°. (See p. 78.)

The characteristics (such as proof, congenerics) of the best fortifying brandy to be used for a given wine are not known. Experience has shown, however, that better-flavored dessert wines are obtained when they are fortified with fortifying brandy made from the same variety of grapes as is used in making the wine. This is particularly true of fruity wines such as muscatel. A neutral-flavored fortifying brandy, however, blends better with most wines than one that is either off-flavored or that contains too high a concentration of esters, such as may be obtained from an aromatic grape like the muscat varieties. The longer the brandies are aged, the better will they blend with the wine. Aging of fortifying brandy, however, is seldom practical.

AGING

The process of aging of dessert wines, like that of table wine, consists in the elimination of undesirable substances—such as suspended yeast cells and other organic matter, excess cream of tartar, tannin—loss of harsh yeasty and new brandy flavors, and the formation of aromatic compounds particularly agreeable to the taste and smell. The rate of aging of the dessert wines is slower than that of table wines and the conditions under which they are aged are quite different.

Settling.—The newly fortified wine is racked off the lees that settle out after fortification and is pumped into storage. If the storage space in the fortifying room is limited, fining and filtration may be used to produce a more rapid flocculation of the crude lees. The prompt removal of the yeast cells from the new wine is desirable to prevent autolysis (or endogenous metabolism) of the yeast cells. Autolysis liberates strongly reducing enzymes and proteins, which not only inhibit oxidation of the wines and produce unpleasantly tasting and smelling compounds, but also favor the growth of lactic acid bacteria and so render the wine more susceptible to bacterial spoilage.

After the wine is pumped into storage, it is allowed to remain in full tanks for about 4 to 6 weeks and is then racked from the lees. The tanks should be kept filled as far as possible, just as for unfortified wines, to avoid the excessive oxidation that occurs in the presence of too much oxygen and to minimize the increase in volatile acidity, which, although it occurs at a much lower rate than is the case with table wines of lower alcoholic strength, does take place. After the first racking the wines in

the various tanks are classified by tasting and analyzing, blended, fined with gelatin and tannin or bentonite, and then stored.

Treatments during Aging.—During aging dessert wines are given special treatment required to bring out the characteristics desired. The flavor of the California-sherry-type wines is developed by a process of caramelization and oxidation at moderately high temperatures. Heating is also used to develop the flavor of Marsala and Madeira types but should not be used for the Angelica or port types, which are best if they age naturally. If certain colloids are present, pasteurization may be practiced to coagulate them. It is also sometimes used to bring about a better blending of the fortifying brandy and wine, but in any case it should not be prolonged.

The slow oxidation of wine and the low rate of esterification under the ordinary storage conditions result in a slow natural aging. The size and kind of tank used for storage and the storage temperature are important factors in determining the rate of aging. It is well known that wine mellows more rapidly in small tanks than in large, possibly because of the more ready access of oxygen by diffusion.

Containers.—Oak is the preferred of all woods, and oak ovals are prized even today as storage containers for wine. It is believed that the oak exerts a beneficial effect on the wine. Although the presence of certain oxidizing enzymes in wood was shown to aid the aging of sake[70] (a Japanese fermented cereal beverage), it is improbable that similar enzymes are present in the old and much used oak ovals. Furthermore, particular care is taken to remove from new containers as much as practical of the oak extractives, which would give the wine an unpleasant harsh flavor.

Storage in oak even for a short period improves the flavor of dessert wine; the quantity of oak extractives that may be present in a wine without injuring its flavor varies with the type. The heated wines with a rancio flavor tolerate more oak flavor than fruity wines like muscatel and Angelica.

Chemical Changes.—The conditions of aging and the changes that result in aging of dessert wines are similar in general to those obtained in table wines. (See Bulletin 639, p. 89–91). During aging, decreases occur in extract, alkalinity of the water-soluble ash, total tartaric acid, cream of tartar, color, and tannin. These decreases are all accounted for

[70] Higasi, Tuneto. The oxidizing action of "Sugi" wood. Institute of Physical and Chemical Research, Japan, Bul. 8:831–38. 1929. *Abstracted in:* Chemical Abstracts 24:458. 1930.

Yamada, Masakazu. The oxidizing action of cryptomeria wood. Agricultural Chemical Society of Japan Jour. 6:168–77. 1930. *Also in:* Agricultural Chemical Society of Japan Bul. 6:9–11. 1930. *Abstracted in:* Chemical Abstracts 25:718. 1931.

by oxidation and the precipitation of wine lees composed of cream of tartar and oxidized color and tannin. Volatile acids and volatile esters increase slowly. Heating increases the formation of volatile neutral esters. The high alcohol content of the dessert wines favors the formation of larger amounts of esters than in table wines. (See p. 19.) Aldehydes and acetals form more rapidly and in higher concentration than in table wines.

The changes in alcohol content depend on the initial concentration, size of container, thickness and nature of the walls of the container, and the humidity and temperature of the surrounding air. Dessert wines stored in large containers in atmospheres of low relative humidity decrease in alcoholic content, but when stored in small oak barrels they may increase in alcohol content. The limiting factors are the differential rates of diffusion of alcohol and water through the pores of the container walls and the relative rates of evaporation at the outer surface.[71]

The pores of white oak offer more resistance to passage of alcohol than of water because of the higher surface tension and viscosity of alcohol; and at the surface the rate of evaporation of water will depend on the relative humidity.[72] (See also p. 15.)

Time.—The amount of aging required depends on a number of factors. The first consideration is the quality of the wine. Poor wines do not adequately profit by aging and should be blended and finished for sale early. Good dessert wines increase in quality for a number of years, the rate of aging depending on the factors previously mentioned: type and size of container, methods of handling, temperature of storage, humidity, and type of wine.

Where the container is very large, dessert wines may be kept a number of years with relatively little aging. On the other hand, when the wines are heated, aging is rapid but the quality is not always increased. (See p. 61.) Wines should not be aged in wood so long that they acquire undesirably high woody aromas or flavors.

Foaming.—Newly fermented wines contain surface-active substances which lower the surface tension of the wine and cause it to foam during agitation. This may cause inconvenience in the handling of the wine in the winery. On aging, however, this tendency to foam is decreased, and well-aged wines do not froth or foam. Even champagnes, although they retain carbon dioxide gas like beer, do not foam as the gas is released, unlike beer.

Quick Aging of Wine.—Filtration or fining or both to remove sus-

[71] Fabian, F. W. The role of wood in the ageing of wine. Wooden Barrel 3:14, 22–23, 25, 27, 29. 1935.

[72] Henrichs, C. G. No substitute for white oak barrels for aging whiskey. Beverage News 33(3):14. 1934.

pended material more rapidly, refrigeration to remove excess cream of tartar more rapidly, aeration to hasten oxidation, and pasteurization have all been used in hastening maturation of wine. Only a few of the processes suggested for quick aging are desirable or practicable. Permission from the Alcohol Tax Unit of the Bureau of Internal Revenue must be obtained before applying any procedure. Heating[73] in the presence of air and oak extractives may be used for some sweet wines, particularly those like sherry in which caramelization is not objectionable. But because of the danger of forming excess acetaldehyde, and of disturbing the delicate balance between the constituents of the wine, which would result in subsequent clouding, quick aging is not recommended for the better wines.[74]

All of the quick-aging processes now in use are defective in that they merely increase the rate of the oxidative changes and do not materially increase the rate of the particular esterification processes which give the beverage its delicate bouquet and aroma. Thus the quickly aged beverages may be palatable, but they lack the quality and character of the naturally aged product. There is some evidence, however, that the esterification processes may be speeded up by the use of catalysts. More promising are the possible applications of biologically controlled aging through the use of selected strains of various microörganisms.

Of the various electrical processes tested in the laboratory, the most promising at present is an electrolytic process in which an attempt is made to combine the desirable features of the hydrogen reduction process with that of the oxygenation process.[75] The wine is reduced at one electrode and oxidized at another. This process brings about an especially rapid blending of the fortifying brandy with the wine. Other electrical processes including ozonization have been suggested, but for the most part they are not suitable to California conditions.

WINERY DESIGN, EQUIPMENT, AND OPERATION[76]

The general principles governing the location, size, and construction of wineries for the production of dessert wines are similar to those for plants producing table wines, which have been previously discussed in Bulletin 639, with the exceptions noted on the following pages.

[73] Cruess, W. V., and M. A. Joslyn. A method to age wine. Fruit Products Journal 13:365, 379. 1934.

[74] Fain, J. Mitchell, and Foster Dee Snell. Artificial aging of spirits. Industrial and Engineering Chemistry, news edition 12:120–22. 1934.
Joslyn, M. A. Possibilities and limitations of the artificial aging of wines. Fruit Products Journal 13:208, 241. 1934.

[75] Joslyn, M. A. Electrolytic production of rancio flavor in sherries. Industrial and Engineering Chemistry, industrial edition 30:568–77. 1938.

[76] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 172.

DESIGN

The layout of a winery producing dessert wines differs considerably from that of a plant devoted to table wines. The generally larger size of such wineries and the greater degree of departmentalization which is necessary are primary differences.

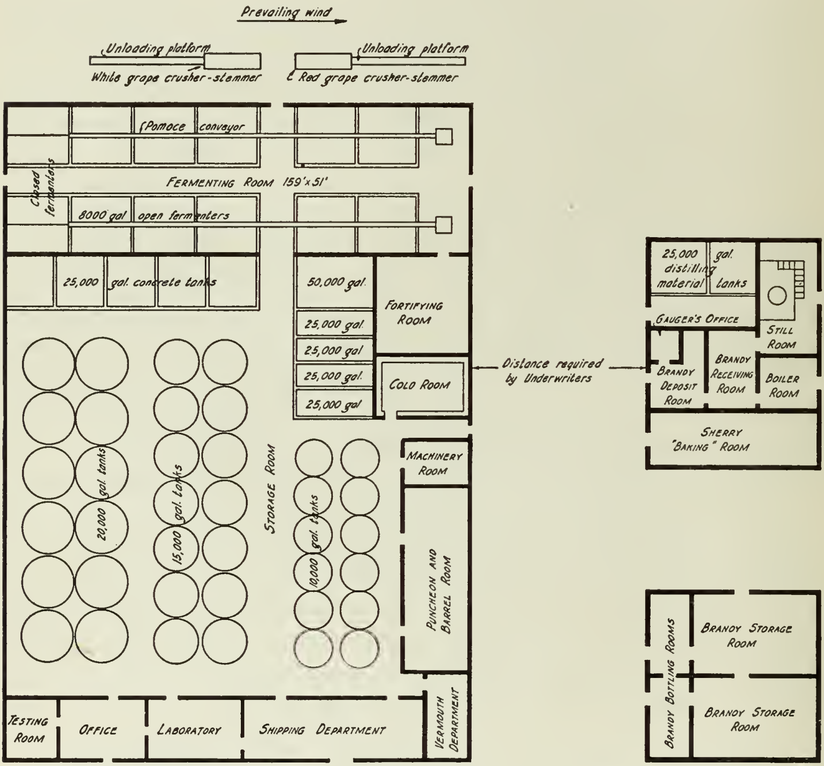


Fig. 3.—Schematic floor plan of a winery and distillery for the production of dessert wine, vermouth, and brandy.

A diagrammatic sketch of a plant handling from 7,000 to 10,000 tons of grapes per season is given in figure 3. The fermenting room in the sketch contains twenty 8,000-gallon open concrete fermenting vats and four closed tanks of the same or larger size. The cost of concrete fermenters is somewhat greater than that of redwood fermenters. But if a sufficient number of concrete fermenters are constructed, the cost per tank is reduced. Further, their cost of upkeep is less than that of redwood and their utilization of space is better. If smaller fermenters are desired or if special types of fermenters are constructed, they can be constructed

at the end of the fermenting room nearest the presses, and two or all of the fermenters at that end of the room may be removed. Production of about one-half million gallons of dessert wines a year, during a season of not less than 8 to 10 weeks, is contemplated.

In the storage section of the winery, concrete, redwood, and oak storage containers are shown. The total capacity of this portion of the cellar is about one million gallons. This size of winery presupposes the sale of about one third of the new wine in the year following its production

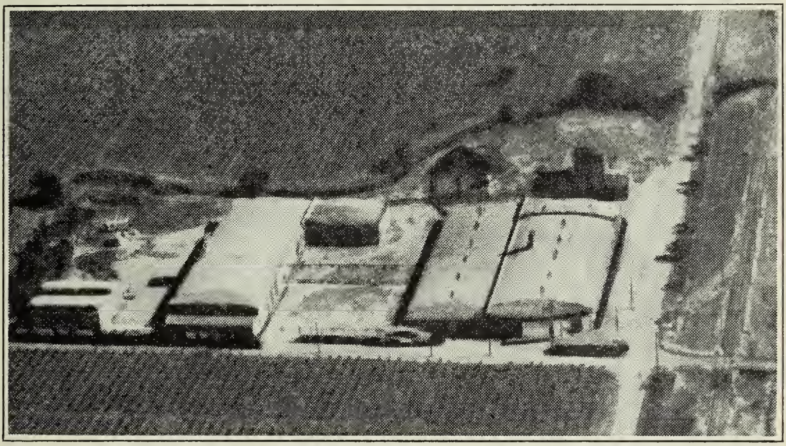


Fig. 4.—Aerial view of a typical large winery and distillery.

and of about 15 per cent in each year from the second to the fifth year. The remainder is aged for special bottlings or for blending purposes. About 15 per cent each year is either lost in racking or distilled because of defects. Such a winery would dispose of its ordinary wines in bulk during the first year and would gradually build up a stock of quality dessert wines. The rate of turnover of wine in many California dessert wineries is far too rapid for producing quality wines. More space for barrel and puncheon storage should therefore be provided.

Other departments common in such wineries are still, fortifying, brandy-receiving, machinery, boiler, and sherry rooms. Space is also provided for a cooper shop (in the storage room), a vermouth department, a shipping and bottling room, and for office, sales, and laboratory space. The sketch in figure 3 is diagrammatic and is intended only to indicate the general relation of the parts of a winery to each other. The actual layout of a somewhat larger commercial winery is shown in figures 4 and 5.

For the production of exclusively bulk-quality wines, a much simplified form of design is possible. The size of the container is increased—

more and larger concrete fermenters and storage containers being provided—and the puncheon and barrel rooms are removed.

No adequate cost surveys are yet available to indicate the overhead of the very large winery as compared to the medium-sized or small plant. The general tendency for wineries producing dessert wines has been towards plants exceeding one million gallons in storage capacity.

For plants devoted entirely to the production of bulk-quality dessert wines, table 25 is suggestive of the type of containers required.

The larger the winery the greater the amount and proportion of very

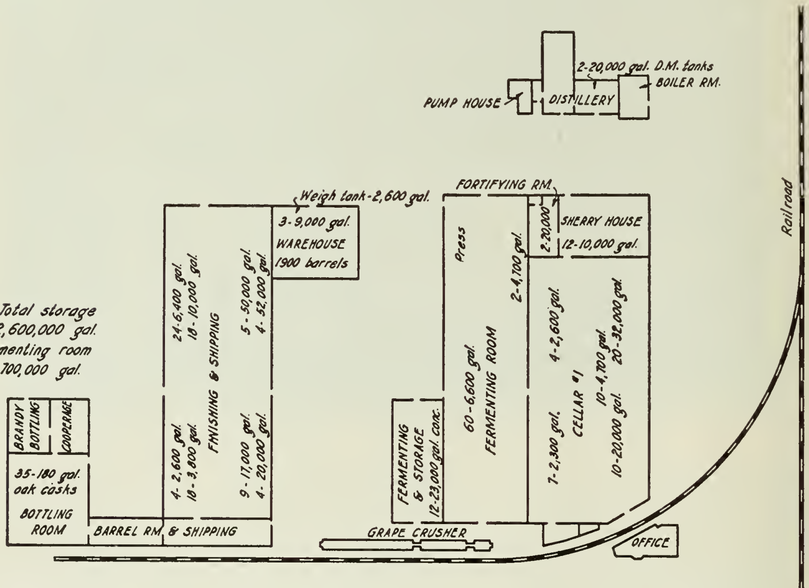


Fig. 5.—Floor plan of the winery shown in figure 4; the number and size of the cooperage in the various cellars is indicated.

large containers required. Plants exceeding one million gallons in capacity will find it convenient to have a number of very large containers available for blending and storage.

In the design of a new winery, the services of a competent architect are very desirable. The particular site and the peculiar needs of the proprietor can then be satisfied. No matter what the present intentions of the owner, provision should always be made for future expansion.

The majority of present California wineries are the result of remodeling previous wineries or buildings. Many are therefore not economically arranged nor properly constructed. Modernization of these plants would be an advantage, reducing the cost of production, increasing the quality of the wines, and facilitating the operation of the plant.

EQUIPMENT

Crushers, Stemmers, and Fermenters.—The equipment for a dessert-wine plant is fairly simple, but it must be ample, both in amount and capacity. The crushing and must-pump facilities particularly should be adequate to handle peak loads. Usually it is desirable to provide separate crushers for red and white grapes. Two moderate-sized crushers are better than one very large crusher. The must lines from the crusher-stemmer to the fermenting room should be of corrosion-resistant metals which can be easily cleaned.

Adequate fermenting-room facilities (see fig. 6) are not only of great assistance to the wine maker, but make possible the more intelligent

TABLE 25

Number and Size of Containers for Bulk Wineries of Various Sizes

100,000-gallon winery		500,000-gallon winery		1,000,000-gallon winery	
Tanks	Size	Tanks	Size	Tanks	Size
number	*gallons*	*number*	*gallons*	*number*	*gallons*
1	25,000	2	40,000	15	40,000
6	10,000	10	35,000	9	35,000
3	5,000	2	25,000	2	25,000
..	......	6	10,000	3	10,000

Source of data:
Levine, S. Efficient winery operation. The Wine Review 6(5):7–9. 1938.

handling of the musts so that better wines are produced and there is a better utilization of the pomace material. The size of the fermenters should ordinarily not exceed 10,000 gallons and, for special fermentations, fermenters of only 500 to 1,000 gallons are useful.

Sumps adequate in number and size should be provided for drawing off wine and for transfer of wine. Special diffusion-tank systems for leaching the pomace have been used in some California wineries.[77]

It is usually better to provide cooling coils in the fermenters, but portable heat exchangers are also useful. Special sumps with a large number of cooling coils are sometimes provided to facilitate cooling.

Most California wineries either do not press or else use all of their press wine for distillation. The screw-type continuous press (fig. 7) is the best choice if the press wine is to be used for distillation.

Pure-Culture Tanks.—Near or in the fermenting room, small containers for preparing pure cultures should be constructed. A small concrete or glass-lined tank on top of a larger one is the usual arrange-

[77] Turbosky, M. Musts for sweet wine production. The Wine Review 5(9):12–14. 1937.

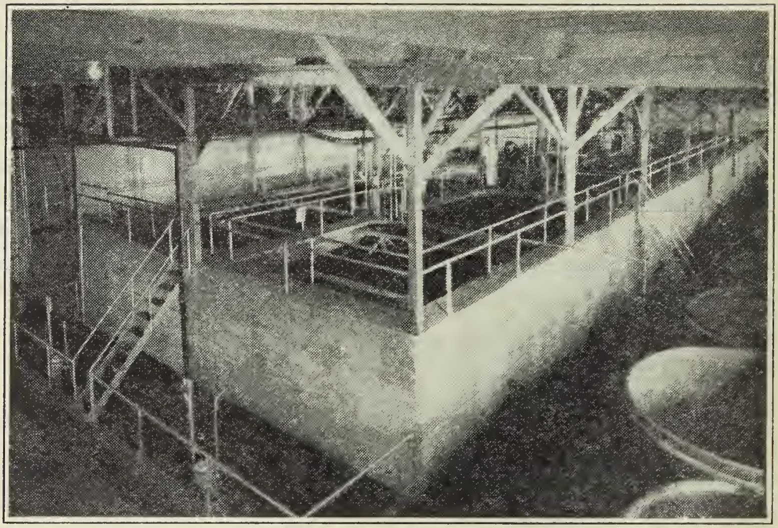


Fig. 6.—Fermenting room with large concrete fermenters. Note particularly the drainage sumps under the fermenters. This arrangement saves considerable space. (Photograph by courtesy of the Wine Institute.)

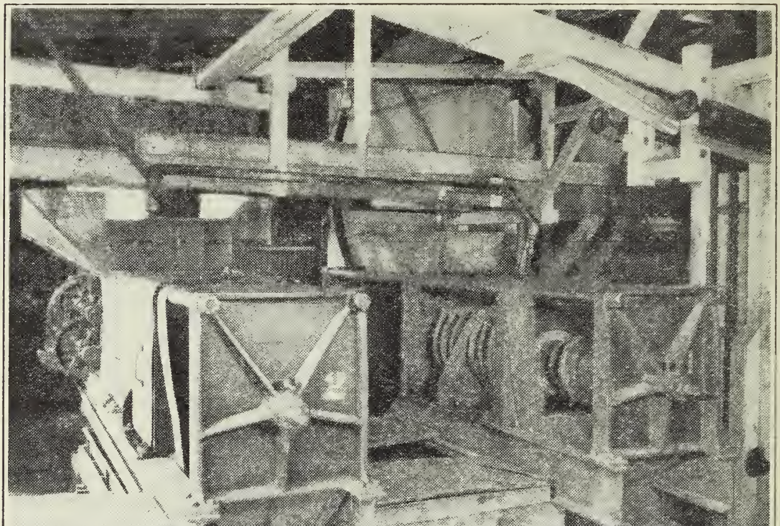


Fig. 7.—Two large continuous presses. The press at the right has the cover removed to show the screw. Notice also the pressed pomace coming out. The pomace drops into the conveyor located below the presses. (Photograph by courtesy of the Wine Institute.)

ment. Piping from the larger pure-culture tank to the fermenters throughout the cellar is also useful. In large wineries intermediate tanks of a size sufficient to provide regularly 2 to 3 per cent culture for the fermenters are necessary. Some dessert-wine plants use their pure-yeast culture only early in the season.

Conveyors.—For handling the pomace, continuous-chain conveyors running in concrete troughs are now almost universally used. Such conveyors should be kept clean *during* the vintage season or they will

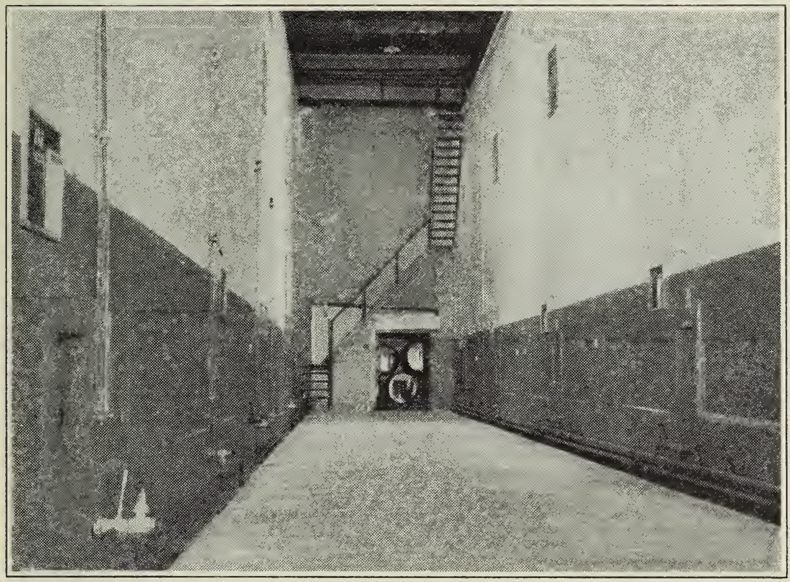


Fig. 8.—Concrete storage tanks in a California winery. Note the measuring tubes on the outside of the tanks and the gutters beneath the outlets for drainage purposes. (Photograph by courtesy of the Wine Institute.)

serve as breeding places for bacteria and fruit flies. These conveyors lead directly to the presses. Small motor-powered elevators are now commonly used to raise the pomace from the floor of the fermenter to the conveyor. In some wineries the pomace is washed out of a manhole in the side of the fermenters and into a conveyor running at their base.

The fermenting room should be equipped with sufficient permanently installed, corrosion-resistant pipe and pump facilities to move the fermented wine quickly to the fortifying room or to the still room.

Storage Equipment.—The size of containers for the storage of the wines is particularly important in California, where redwood and concrete containers of 25,000- to 100,000-gallon capacity are commonly used for dessert wines (fig. 8). The rate of penetration of oxygen through thick concrete containers, for example, is considerably reduced.

In addition, the extraction of desirable materials from the wood is a factor which is entirely absent when concrete is used. Finally, the ratio of surface to volume is much smaller with large-sized containers, and even if the rate of penetration of oxygen is the same, less will be absorbed per gallon of wine. The amount of material dissolved from the wood is also reduced by this factor. The number of square inches of surface exposed per gallon of wine in various types and sized containers is given in table 26.

Vintage dates on labels will not mean the same as far as maturation of the wine is concerned when different sizes of storage containers are

TABLE 26

SQUARE INCHES OF SURFACE EXPOSED PER GALLON OF WINE IN CONTAINERS OF VARIOUS CAPACITIES AND SHAPES

Type container	Dimensions	Capacity	Inside surface per gallon
		gallons	*square inches*
Barrel	33 × 68.5 × 80 inches*	50.0†	54.6
Port pipe	40 × 73 × 91.5 inches*	65.8†	49.3
Sherry butt	48 × 86 × 112 inches*	134.3†	38.6
Redwood tank	112.5 × 162.5 inches‡	10,000	9.32
Concrete tank	(11.16 feet)^3§	10,000	10.48
Redwood tank	19 feet 4½ inches × 29 feet 6½ inches‡	100,000	4.56
Concrete tank	(27.73 feet)^3§	100,000	4.86

* Height × circumference at head × circumference at center, outside (inside dimensions used in calculation).

† Capacity obtained by gauging.

‡ Inside height × inside diameter.

§ Inside dimensions.

used. With wines stored in 135- to 160-gallon puncheons, three or four years are considered to be about minimum for the wine to become smooth and to acquire bottle ripeness; much longer periods are frequently used in European countries for dessert wines. Wines stored for the same time in larger containers usually are not so smooth and have an undesirable aroma of the fortifying brandy because of their reduced rate of aging. It is not intended to imply that the rate of aging of wines is directly proportional to the square inches of container surface exposed per gallon of wine. But this and the influence of the wood itself on the aging are factors which are far too frequently neglected in the handling of quality dessert wines in California. With ordinary wines, of course, the aging is not so important and these factors can be and commonly are overlooked.

The best wines should accordingly be aged in oak barrels or puncheons. The lesser-quality wines are stored in redwood or concrete containers.

New Containers.—New concrete vats and tanks should be washed, soaked with a tartaric acid solution, and, if possible, filled for some time

with good distilling material or preferably with clean but ordinary dessert wine. Various coatings are used by some wineries. Unless the wine is to be stored for some period in concrete, this is unnecessary. Even then it is difficult to find a *permanent,* nonflaking coating. Glass-lined concrete containers have not, so far, been much used in California, although they are preferable.

New redwood tanks should be soaked with a warm alkaline solution

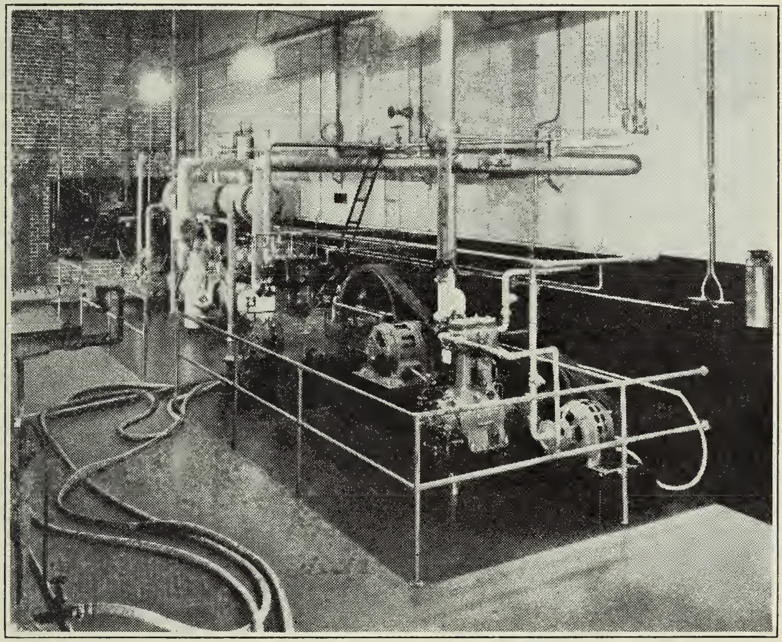


Fig. 9.—Refrigeration equipment in a large California winery. Smaller wineries can obtain smaller and more compact units for their needs. (Photograph by courtesy of the Wine Institute.)

and water. The storage or fermentation of distilling material and dessert wine in such tanks is also useful.

Oak containers are usually soaked with an alkaline solution, steamed, filled with water, and, if possible, temporarily conditioned with clean distilling material and sound wine of low quality.

Refrigeration.—The generally warm conditions of California wineries slow down the rate of deposition of tartrates. Cooling the wines to a temperature of below 25° F hastens removal of tartrates and also usually facilitates clarification. (See p. 126.) The solubility of air in wines at low temperatures also increases the oxygen content of the wine, and consequently the rate of oxidation when the wine is once more placed at ordinary temperatures.

Some California wineries provide a room which may be held at low temperatures, while others insulate concrete tanks and equip them with cooling coils (see fig. 9). A cold room, although expensive, is a great convenience and should be provided if possible.

Other Equipment.—Heat exchangers are standard equipment for modern wineries. Portable heat exchangers are useful, or a permanent installation can be arranged in the storage room and the wine pumped to it. Flash pasteurizers in which the wine is rapidly raised to a high

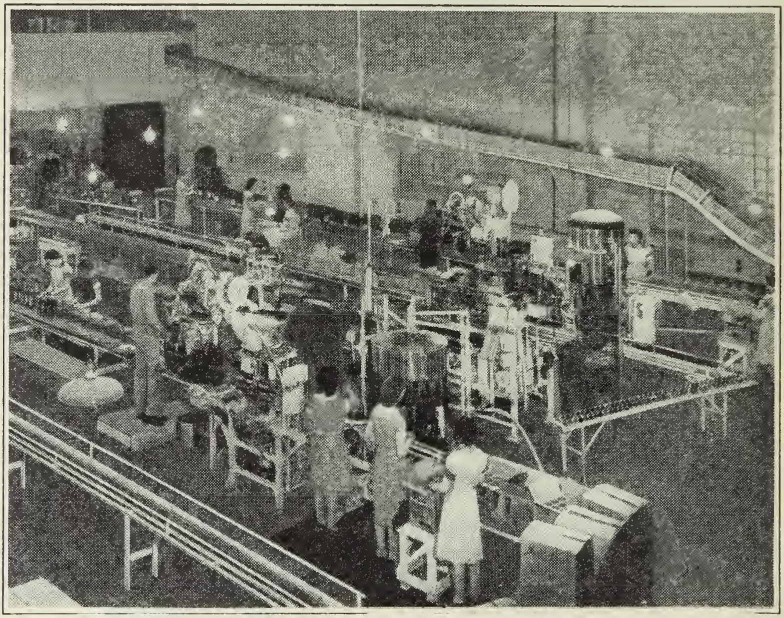


Fig. 10.—Bottling room in a large California winery. Note the automatic bottlers and cappers. (Photograph by courtesy of the Wine Institute.)

temperature and then very quickly reduced are considered most desirable.

Numerous types of filters are found in California wineries. Plate and frame filters, in which the use of filter aids is reduced, are usually satisfactory. At least one pad filter for polishing purposes is necessary. Heat exchangers and filters should be constructed of corrosion-resistant metals. (See Bulletin 639, p. 58–59.)

Rubber hoses are very important pieces of equipment. Tasteless, odorless hoses of various sizes and lengths should be provided. Sloping racks on which the hoses can be drained after use are essential. The life of the hose can be considerably increased by proper handling, especially when not in use.

Automatic bottle washers (fig. 10) are great timesavers, and their efficiency exceeds that of hand-washing. The filling equipment should be kept clean. Use of corrosion-resistant metal for the fillers is essential.

SANITATION AND MAINTENANCE

Winery Design.—Elimination throughout the winery of all nooks and corners which are difficult to clean is the first requirement in sanitation. Construction of concrete piers for the vats and tanks, adequate sloping of the floors to the drains, and concrete floors are very desirable. The floors should not be so smooth as to be slippery nor so rough as to catch excessive amounts of dirt and organisms.

Services.—Hot and cold water and steam outlets throughout the fermenting and storage rooms should be arranged at the time of construction of the winery. Regular use of plenty of water on the floors should be the standard practice. All must and wine pipes must be easily drainable and so constructed that there are no nonflushable sections.

Care of Containers.—Empty concrete containers are the simplest to keep clean. A thorough washing and sterilizing with a dilute hypochlorite solution is about all that is necessary.

Open redwood fermenters may be filled with limewater and, if the surface film of calcium carbonate is not broken, they will remain "sweet" for several months. Painting redwood fermenters with lime and allowing them to dry out is also a common practice. The hoops should be tightened soon after the fermenters are emptied; and the lime solution should not be too thick else it will be too difficult to remove.

Closed redwood tanks are usually left empty without treatment, but they should be scrubbed, washed, and sterilized with a dilute hypochlorite solution before such storage. Releasing sulphur dioxide gas into the tank occasionally and tightening the hoops regularly is also helpful in keeping such containers in a good condition.

Empty sherry-cooking tanks are very difficult to keep clean. Usually the measures mentioned for redwood tanks are used. Keeping these tanks full of wine is a better procedure. After a few years' use, sherry-cooking tanks leak so badly (fig. 11) that the soft staves must be removed and the internal and external surfaces thoroughly cleaned.

Keeping empty oak cooperage in good condition is a difficult problem. Cleaning thoroughly and storing in a room that is not too dry, too warm, nor subject to drafts is the best procedure. A dilute solution of sulfur dioxide and sulfuric acid is sometimes used to fill such containers. Most wineries handling dessert wines find it possible to fill most of their empty oak cooperage with wine from concrete containers, which reduces the storage problem of empty wooden cooperage.

The services of a skilled cooper to care for cooperage is good economy in any winery.

When barrels are returned to the winery, they should always be soaked with a dilute alkaline solution (such as soda ash) and thoroughly washed. If the barrel has become moldy, it may require steam, hypochlorite, or scraping and recoopering.

Tank cars have become a source of much contamination, since they

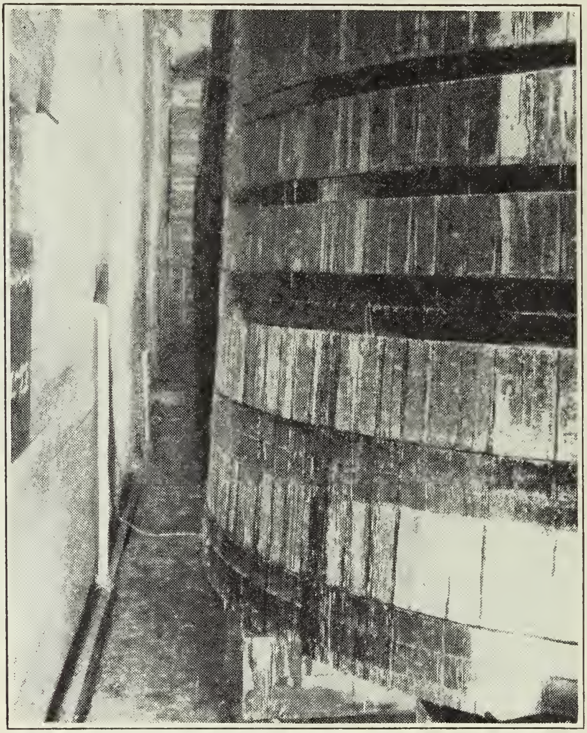


Fig. 11.—Outside of a redwood sherry tank during "cooking." Note the leakage from between the staves. (Photograph by courtesy of the Wine Institute.)

are usually returned in a very insanitary condition. Distributors should be asked to clean such tanks when they are emptied, or at least to wash them out. When they are returned to the winery, they should be scrubbed, using soda ash, and the lining should be examined for any defects.[78]

Returned empty containers and recently emptied storage vats, because they contain alcohol vapors, constitute a fire hazard. Smoking or lighting of matches in their vicinity should be prohibited.

[78] Quaccia, L. The care of cooperage. The Wine Review **7**(7):7–8. 1939.

Many dessert wineries are troubled with the growth of fungi on the outside of the tanks. Recently proprietary germicidal paints have been developed for the control of such growths in the food industries, and they should prove useful in wineries as well.[79]

The cask borer (*Scobicia declives*) is only occasionally found in redwood tanks. Oak tanks painted first with alum and then linseed oil are immune to attack. Keeping oak casks in the dark is also helpful in preventing attack.

Antiseptics.—Cleaning solutions of varying degrees of strength are available for use in the winery. For mild cleaning, dilute solutions are satisfactory. But where extreme contamination has developed, stronger solutions are necessary. At present, for general winery-cleaning purposes, solutions yielding free chlorine are used in most wineries.

Cleaning bottles (see p. 141) and other special problems may require a different type of solution. The antiseptic solutions must, of course, not come in contact with wines.

Health of the Workers.—According to Delaunay,[80] winery workers are not subject to any particular occupational diseases. The humidity, darkness, and lack of aeration are health hazards in some wineries. A survey of California wineries by Russell, Ingram, and Dakan[81] showed that 76 per cent of the employees were exposed to alcohol vapors; 53 per cent to carbon dioxide; 21 per cent to excessive dampness; and smaller percentages to sulfur dioxide, alkalies, carbon monoxide, organic acids, and various other substances. They recommend adequate ventilation, good lighting, protective clothing, safety directors, and other measures to safeguard the health of winery workers.

DIRECTIONS FOR MAKING RED DESSERT WINES[82]

The chief type of red, sweet dessert wine produced in this state is California port, although a red muscatel is occasionally made. In the eastern United States, where native species of *Vitis* or hybrids of native species and *V. vinifera* varieties are grown, red dessert wines, such as Concord, Ives Seedling, and the like, are occasionally made. All of these wines resemble each other in their color, alcohol percentage of 18 or 21 per cent, and sugar concentration of at least 6 per cent. (See p. 22–24.)

[79] Epstein, S. S., and F. D. Snell. Antiseptic and germicidal paints. Industrial and Engineering Chemistry, industrial edition 33(3):398–401. 1941.

[80] Delaunay, H. Hygiène des ouvriers du vin. Chimie et Industrie, Special no., p. 615–18. 1925.

[81] Russell, J. P., F. R. Ingram, and E. W. Dakan. Industrial hygiene survey of California wineries. California Dept. of Public Health, Industrial Hygiene Service Investigation Rept. No. 2. 36 p. 1939.

[82] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 172–73.

Varieties suitable for California port are given on page 38 and for red muscatel on page 36.

HARVESTING AND FERMENTATION

Grapes intended for red dessert wines should be picked and transported to the winery with the same general care as those used for red table wines. Picking only good-quality fruit of suitable varieties at the proper stage of maturity—25° to 29° Balling (see p. 35)—and transporting the grapes to the winery without delay or metal contamination and in as cool a condition as possible are the elementary requirements for harvesting and delivery of the fruit to the winery. Delay in delivery, so that fermentation starts in bruised fruit before crushing, is very undesirable with the fruit of low acid and high pH used for dessert wines, since bacteria develop particularly well under these conditions in the warm interior valleys of California. Furthermore, grapes for dessert wines are harvested at a more advanced maturity, hence they are more susceptible to handling injuries than those for table wines. They should therefore be handled *at least* as carefully as the grapes intended for table wines. The belief that dessert wines are free of spoilage because of the short fermentation and that the grapes may therefore be handled in an insanitary fashion is entirely erroneous. Contamination of the must by improper handling frequently results in serious spoilage losses, or in wines which require time and costly treatments to finish.

Crushing.—The stemming and crushing is done with the usual equipment and the must then pumped to the fermenters—either redwood or concrete commonly being used. Usually these are open vats. A better manipulation of the cap is possible if they are relatively shallow so that the depth of fermenting mass is small or if submerged cap fermenters are used.

A small amount of sulfur dioxide is introduced into the must while filling (see p. 42). The amount may be as small as 50 parts per million for the best grapes, since the fermentation period of dessert wines is short. But larger amounts are used under very warm conditions or with fruit of poor quality. Either potassium metabisulfite, sulfur dioxide gas, or a 6 per cent solution made from one of these may be used. (See also Bulletin 639, p. 43–45.)

Pure yeast cultures (see p. 43) should be used, at least at the start of the season. They are added an hour or more *after* the sulfur dioxide has been applied. Two or 3 per cent of the pure yeast culture should be added. Various strains of wine yeast are used for red sweet wine, but in view of the restricted extent and period of the fermentation, there does not appear to be any advantage in using a special strain for these

wines. The contribution of mixed yeast cultures to dessert-wine production is not known. If such cultures greatly delay the fermentation, their influence may be beneficial in permitting longer contact of the skins and juice and hence greater extraction of color and flavor. The possibility of flavor contamination and the formation of undesirable hazes in the wines must be taken into consideration when unrestricted wild yeast growth is permitted.

CONDUCT OF THE FERMENTATION

The primary problem in making red dessert wines is the adequate extraction of color from the skins during the restricted period of fermentation before fortification. In the making of red muscatel, flavor extraction from the skins is also important.

Temperature.—The period of fermentation cannot ordinarily be extended too long because of the consequent increase in the number of fermenters which will be required. Nevertheless, increasing the period of contact of the skins with the fermenting juice is a practical means of extracting a larger amount of color. A moderate temperature in the fermenter is a partial means of prolonging the period of the fermentation as well as securing a cleaner fermentation. A number of methods for securing or maintaing a lower temperature may be utilized. Crushing the grapes in the coolest possible condition is one. Cooling either by coils in the tanks or by pumping the fermenting juice through a heat exchanger is the most satisfactory measure. The use of sulfur dioxide alone is not a satisfactory means of slowing down the fermentation, although it will have some effect through its control of the temperature.

Overheating in the cap is to be studiously avoided, for it may result in wines of a "cooked" flavor. Sticking is not a problem in making red dessert wines.

METHODS FOR COLOR AND FLAVOR EXTRACTION

Management of the Cap.—Proper manipulation of the cap is a most important means of increasing the extraction of color and flavor. The traditional Portuguese method is to keep the cap *constantly* punched down by treading. A more sanitary substitute for this method is to use long poles which have a flat board attached to the end for punching down. The punching-down must start within a few hours after crushing and should be kept up as continuously as possible. The submerging of the skins not only increases the color extraction by increasing the contact of the liquid and the skin, but also increases the extraction of other soluble constituents such as sugar and flavoring matters. The constant movement of the skins through the liquid also promotes this dissolution

by the mechanical breakdown of the skins. Too much stress cannot be laid on the necessity for continuous punching down if the best results are to be obtained. This is particularly important if partially dried berries are present. A mechanical means of punching down would be very desirable, since it is very difficult to punch down the cap in a large tank.

Note: Adequate safety measures to prevent asphyxiation—smothering due to excess carbon dioxide—should always be taken where men are working on the top or edge of fermenters. Usually two men should work together. Modern air conditioning, such as is found in breweries, will undoubtedly be used in wineries in the future.

Submerged Cap.—Although the submerged-cap system of fermentation does not have the mechanical advantage afforded by punching-down, it does give a maximum submersion of skins in the juice. Tanks with removable wooden tops and concrete tanks with fixed tops through which the juice alone rises are in common use in this state. Difficulties in manipulation and sanitation of the wooden lattice have restricted their use, and closed concrete tanks are now favored. There is a raised ledge around the top of the tank and manholes in the top. A small wooden lattice may be placed below the manhole. This is easier to use than the large lattice over the whole upper surface of the container. (See Bulletin 639, p. 70–72.)

Pumping Over.—Pumping over is another method used for securing color extraction. The inlet hose should be handled by a man in order to spray it over the full surface of the tank. Although pumping over aerates the must, this is not objectionable with red dessert wines unless it excessively speeds up yeast growth and consequently the rate of fermentation. Cooling the must while pumping it over will help to prevent an undue rise in temperature.

Special Methods.—In the large winery, sufficient attention cannot always be given to the laborious details of the techniques previously described for securing maximum color and flavor extraction. In certain districts and seasons, the grapes available are deficient in coloring matter, and in such cases, special methods may be needed even in the small winery. Furthermore, sometimes deeper color may be wanted than can be obtained by ordinary methods. The following procedures are useful for this purpose, but their effect on the quality of the resulting wines is by no means clear. Such methods should, therefore, be used with caution and only after trial has established their effect on the quality, as well as on the color of the resulting wines.

One of the procedures used commercially involves drawing the juice from the skins, heating it to 150° to 180° F, and pumping it back onto

the skins. The color of the skins so treated very rapidly diffuses into the juice, and the whole mass can be pressed in a few hours. The resulting red-colored juice is handled as if it were a white must, except that it should be cooled to about 70° before adding the pure yeast culture. The heat treatment gives a fair pasteurization, and little or no sulfur dioxide need be used.

In this heat treatment, a number of variables must be controlled to secure the best results. The temperature of the whole mass, after pumping back the hot juice, should be at least 140° F. The heating of the juice should not be done with live steam or by any system whereby a portion of the juice is overheated or burnt.

Where equipment is available, heating of the entire mass of grapeskins and juice may be done in steam-jacketed vessels made of stainless steel or some other noncorrodible metal. The amount of color extracted can be increased by raising the temperature above 160° F or by increasing the period on the skins. Tressler, Joslyn, and Marsh[83] state that the heating should not be for too long a period nor at too high a temperature lest too much tannin be extracted.

Amerine and De Mattei[84] have shown that color extraction can also be obtained before crushing by dipping the whole grapes in boiling water for 1 minute. The grapes are then crushed and may be pressed almost immediately, if desired.

The general principle involved in all procedures in which heat is used is that of killing the cells of the skins of the grapes which contain the anthocyanin pigments so that the cells become permeable or at least lose their characteristic semipermeability, which ordinarily prevents the rapid dissolution of the pigments from the skin.

In addition to preliminary color extractions, heating before fermentation and not cooling the must and even purposely "sticking" are used.[85]

PRESSING

In Portugal, partial fortification of the whole fermenting mass before pressing is permitted. This may have the advantage of securing greater color and flavor extraction, but some of the added spirits will be lost with the pomace at the time of pressing. Under present government regulations, such a procedure is not feasible in California, and the must is pressed before fortification.

Where ordinary-quality grapes are being used, only the free-run

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[83] Tressler, D. K., M. A. Joslyn, and G. L. Marsh. Fruit and vegetable juices. 549 p. Avi Publishing Co., Inc., New York, N. Y. 1939.

[84] Amerine, M. A., and W. De Mattei. Color in California wines. III. Methods of removing color from the skins. Food Research 5(5):509–19. 1940.

[85] Berg, A. Color extraction for port-wine manufacture. The Wine Review 8(1): 12–14. 1940.

juice is removed for fortification, while the remaining pomace is watered and used for the production of distilling material for fortifying brandy. If presses are used, the continuous press is commonly utilized because of its convenience and ease of operation, although slightly better musts for fortification are obtained with a basket press.

FORTIFICATION[86]

Time.—The sugar content will be reduced to the proper amount for fortification in 2 to 6 days, the time required depending on the temperature, amount of yeast, and other factors. If the rate of fermentation is rapid, the must should be pressed at a sugar content at least 2° Balling above that at which it is desired to fortify the must. The time required for the alcohol tests and pumping is sufficient to permit the Balling to reach the desired degree.

Sugar Content.—In California wine makers usually wish to produce a red dessert wine of 20 per cent alcohol and 6° Balling. This means an actual extract content in the dealcoholized wine of about 10 to 12 per cent. The proper Balling at which to fortify in order to secure this extract content depends on the original Balling of the must. The higher the original sugar content the lower the Balling at which the fermenting must may be fortified in order to secure a finished wine with an extract content of 10 to 12 per cent soluble solids. Some approximate Balling readings for fortification of grapes harvested at different degrees of maturity are given in figure 1 (p. 49). The data in this figure were taken at the time of fortification and may be somewhat lower than winery figures.

Fortifying Brandy.—In California, brandy of over 180° proof is commonly used for fortification of red dessert wines. According to da Costa[87] and Garino-Canina,[88] the best dessert wines of Portugal and Sicily are produced when the fortifying brandy is of low proof, specifically 152° to 156°. Such a brandy contributes a greater degree of aroma to the wine both before and during the aging and is said to blend with the wine better and to add to its quality on aging. Wines prepared in this fashion, however, must be aged for a longer period of time in order to attain their best quality. According to de Castella:

> The spirit used in fortifying Port is a matter of vital importance, and has con-

[86] See also p. 46 to 58.

[87] Costa, L. Cincinnato da. Le problème des eaux de vie et des alcools—Influence de leur provenance et leur degré dans le vinage. V[eme] Congrés International de la Vigne et du Vin. Rapports, Tome 2, Oenologie. p. 181–89. Editorial Império, Lisbon, Portugal. 1938.

[88] Garino-Canina, E. Sulla valorizzazione dell'alcool de vino sotto il riflesso económico della tecnica vitivinicola. Regia Stazione Enologica Sperimentale di Asti Annuario (Serie II) I:215–21. 1934.

siderable bearing on the character and bouquet of the wine. In the best Douro vineyards a highly rectified silent [neutral] spirit is never used—only a spirit distilled at fairly low strength, and which retains a good deal of the flavor of the wine from which it is made. Its strength when added to the wine is usually 37% over proof [156.4° proof in the United States]. This spirit is often distilled in a pot still, and can, of course, only be made from sound wine. . . . The type of spirit used, and the fact that it is not silent spirit, are points of great interest. . . . It is noteworthy that this special spirit is only used for the high-class wines, which take a long time to mature. . . . For cheap wines, which are to be consumed young, or for slightly increasing the strength of an old matured wine, should such prove necessary, silent spirit, highly rectified, is used.

The merchants of Oporto are most particular in selecting their fortifying spirit. . . . This spirit is, and has been for many years, exclusively made from wine.[89]

Brandy of over 170° proof is said to have a bad influence on the color when fortification takes place on the skins. Before Prohibition there was a widespread prejudice in California against the use of fortifying brandy of proofs of 180° or over due to the reduced color and quality which was supposed to result from their use, and spirits of 170° to 180° were commonly used. We have been unable to confirm this prejudice adequately.

Method.—Government regulations require that wines be placed in a fortifying room (see p. 46) for fortification. The wine to be fortified is therefore pumped from the fermenting room to the fortifying room and the total volume determined by the United States gauger. The alcohol content is determined by the gauger, who also determines the proper amount of brandy required to bring the alcohol content to the desired percentage of alcohol (to 19.5 to 21.0). This amount of fortifying brandy is then weighed out and pumped into the fortifying tank. The amount required is calculated by one of the formulas given previously (p. 52) and by reference to the Gauging Manual (cited in footnote 69, p. 54). A record of these amounts and percentages must be kept on the proper government forms.

In order to stop the fermentation immediately, the added fortifying brandy and must should be promptly and thoroughly mixed. Because of the great difference in specific gravity of the alcohol and the wine, mechanical mixing will be required, especially if the fortifying tanks are large. Continuous pumping over is sometimes used to do this. Release of compressed air in the bottom of the fortifying tank has also been used successfully.

The alcohol content of the wine is then redetermined and the wine pumped to the storage cellar.

Note: All determinations and calculations of the gauger should be

[89] Castella, F. de. Port. Victoria Department of Agriculture Journal 6:176–91. 1908.

checked before fortification. An easy and common method of preventing large errors is always to fill the fortifying tanks to the same height. Experience will then indicate the approximate amount of fortifying brandy required, and gross errors can be eliminated.

AGING

Aging of red dessert wines involves the removal of the lees from the wine and subsequent aging of the wine to the required degree of oxidation and color. The high alcohol content of dessert wines usually prevents undesirable bacterial activity in the lees, but racking the wine from the lees as soon as it falls clear is generally considered prudent. This is particularly advantageous where the wine is contaminated with bacteria, for certain bacteria are able to act in the presence of a high alcohol content (see p. 144). In general, the wine should be racked within a week after fortification and again in the storage cellar within a month. The lees material is usually diluted and used for the distillation of fortifying brandy or for lees brandy. Ordinary-quality wines are stored in large-sized redwood or concrete containers. The best wines are stored in smaller-sized oak containers, for example, in Portugal in pipes of about 140 gallons' capacity.

Treatment.—Under the best conditions—good-quality grapes, clean fermentation, and safe and sufficient storage—the red dessert wines become almost brilliant naturally, and clarification or other treatments need only be considered just prior to shipment if at all.

Wines which do not become clear by themselves within the first six months should be clarified. The usual sequence for such red dessert wines involves cooling to about 20°F either by pumping through a heat exchanger or by the storage of the wine in a room of about this temperature. The wine is left at this temperature for about one week and then is filtered into the storage tanks. It may be fined and filtered before or after such treatment, usually with bentonite or gelatin. If the wine is diseased, various treatments may be necessary (see p. 147).

There has been a large demand since Prohibition for cheap red dessert wines. Early maturation is necessary, since these wines must be delivered to wholesale buyers when young. The treatment of the wines *for this purpose* may involve heating to 110° F for a period of about a week, or electrolytic treatment for a day or two, as well as the measures outlined above for wines difficult to clarify. Additional oxidation by the use of oxygen may also be used advantageously in some cases. There is an economic advantage in moving ordinary-quality wines rapidly, which justifies such practices. High-quality wines should, of course, not be so treated. (See p. 61.)

Storage.—The time required to bring a red dessert wine to its optimum maturity varies with the type of wine, the temperature of storage, the size of container, and the treatments which the wines have received. Red wines of high tannin require a longer period of aging. Wines fortified with low-proof fortifying brandy also require a longer period of aging. The rate of aging is, however, considerably speeded up at warm temperatures.

DIRECTIONS FOR MAKING SWEET, WHITE DESSERT WINES[90]

The chief types of white, sweet, nonrancio-flavored wines produced in this state are Angelica, muscatel, and California white port. Fortified sweet wines are occasionally produced in eastern United States from Catawba and other non-*Vitis-vinifera* varieties by similar procedures or by blending.

Angelica.—One of the early procedures used in southern California, according to Hyatt,[91] for the production of Angelica was to fortify 3 gallons of must with 1 gallon of brandy. Assuming a proof in the fortifying brandy of 140° to 160°, which was the usual range with the pot stills used in those days, the finished wine probably contained from 17.5 to 20.0 per cent alcohol. In the period just before Prohibition, commercial practices approximately followed this tradition, and unfermented or nearly unfermented free-run juice was fortified; but brandy of high proof (170° to 185°) was used for the fortification. Post-Repeal practices have permitted a longer period of fermentation before fortification, but Angelica is still one of the sweetest of the ordinary commercial types of wine (see p. 24). It is interesting to note that the Malaga wines of Spain are also very sweet, but their high sugar concentration is obtained by the use of boiled-down must and the wine is much darker in color than a California Angelica. Varieties suitable for Angelica are given on page 37.

Muscatel.—Muscatel is a fortified wine possessing a distinct muscat flavor and having over 10 per cent sugar. It has been produced in California since the early days but only achieved a large-scale demand during the period just after Prohibition. Its aromatic and distinct varietal flavor is easily recognizable and apparently has strongly impressed the new wine drinkers of the early post-Repeal period. It is not generally considered a quality sweet dessert wine because of its sweetly mawkish character. Special muscatels, such as those made from Muscat

[90] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 173.

[91] Hyatt, T. H. Hyatt's hand-book of grape culture. 2d ed. 279 p. A. L. Bancroft & Co., San Francisco, Calif. 1876.

Canelli, offer some promise of improving the quality of this type of wine. A list of muscat-flavored varieties is given on page 36.

White Port.—California white port is a type which was only occasionally produced in the pre-Prohibition period. It is a very light-colored, white, sweet wine, the water-white appearance being due to the method of treatment used during the finishing process. In the pre-Prohibition period, the decolorization was usually made with bone charcoal, but now activated vegetable charcoal is commonly used. Varieties suitable for Angelica are generally satisfactory for this type of wine. Slightly pink wines produced from varieties such as Grenache, Carignane, and Mission can also be used, for they lose their color during the finishing process (see p. 37).

Owing to the present legal restrictions, wine to be converted into white port must be designated as such at the time of fortification since only this wine is permitted to be decolorized. Since, however, white-port stock may be marketed as Angelica, it is the custom to carry Angelica stock as white port on the winery records.

HARVESTING AND FERMENTING

The picking and handling of grapes for white dessert wines is no less important than that of white table wines. The grape varieties used are usually riper and the resistance of the berry to injury is therefore reduced. The grapes should always be picked with the least possible injury.

Rotten or moldy grapes are higher in enzyme content[92] than sound fruit and should not be picked, if light-colored, fruity, clean, white dessert wines are to be produced. Bruised fruit also frequently yields wines with an undesirable brown color.

Every effort should be made to reduce the period from picking to crushing to the shortest possible time interval. To achieve this, it is important that wineries should arrange picking and transportation schedules with the growers so that the crushing facilities of the winery are not overcrowded at any time by deliveries. One- and two-day delays in unloading trucks (sometimes seen in California) are unnecessary, reduce the quality of the wines, and do not make for good will with the growers or the transportation companies. Undesirable bacterial action and harmful metal contamination are the further penalties for such delays. The metal contamination is liable to be especially serious for white dessert wines if gondola trucks are being used. In general, iron gondola trucks are not advisable for transporting grapes for *wine* making.

[92] Laborde, J. Cours d'oenologie. Vol. I. 344 p. (See especially p. 231–33.) L. Mulo, Paris, France. 1907.

The picking of raisined fruit may yield wines with a dark color and an unpleasant raisin or caramel flavor. The general impression that only raisined Muscat of Alexandria grapes yield highly aromatic muscatel wines is incorrect. Very early harvesting, say at 21° Balling, does result in wines of low varietal flavor. The real reason for the enhanced flavor of late-picked muscats is because both the first- and second-crop grapes are ripe at that time, but usually the varietal flavor is then accompanied by a strong raisin flavor. The best muscatels would result if the first-crop muscats were picked after they reach 26° Balling and *before* they raisin too badly. In some districts the Balling reading at the time raisining begins may be even higher than this (at Escondido, in southern California, for example). But unfortunately, in the districts where the greatest acreage of muscats is planted, the high summer temperatures result in sunburning and raisining before all the grapes, the second as well as the first crop, are really ripe. The unripe second-crop muscats would not dilute the flavor of the first-crop muscats if the first crop were picked separately. The grower and winery must therefore choose between three possibilities: too early picking and deficiency of flavor; picking only the ripe first-crop grapes at their optimum maturity (which is more expensive); and late picking of all the grapes and having a darker-colored, more raisin-flavored wine. Some pre-Prohibition wineries chose the second alternative and then used the second-crop muscats for making muscat distilling material.

Crushing.—The usual crusher and stemmer is used and the must pumped to the open redwood or concrete fermenters. The rotary crushers should be operated at a high speed with only a moderate load when shriveled or raisined fruit is being crushed, every effort being made to crack the skins. Practically all wineries stem the grapes at the same time, and this is a desirable practice.

Grapes intended for Angelica and California white port are usually separated from the skins shortly after crushing, particularly if the white port is being made from grapes which have some pigment in the skins. Some wineries simply drain the free-run juice for fermentation and wine making and then dilute the remaining pomace with water for the production of distilling material. With inexpensive grapes, when grapes are plentiful, or when there is need of large amounts of fortifying brandy, this practice is justified; otherwise, the grapes should be gently pressed and the press wine added to the free-run juice, while the press cake only is diluted and used for making distilling material.

Muscats are left in the skins from 6 to 36 hours after crushing before pressing, in order to extract more of the flavor from the skins; pressing is also easier after a period of fermentation. The time on the skins

should not be too long else too much tannin and coloring matter will also be extracted.

Conduct of the Fermentation.—Sulfur dioxide is added to the juice or to the must as soon as possible after crushing. If the pressing is to be delayed more than a couple of hours, the sulfur dioxide should be added before pressing. The amounts to add depend on the condition of the grapes and the temperature of the fermentation (see p. 42). At least 75 parts per million are ordinarily added. Potassium metabisulfite, sulfur dioxide, or a 6 per cent solution of one of these may be used. The sulfured must should not be allowed to come in contact with any metal surfaces. (See also Bulletin 639, p. 39–45, 88.)

Pure yeast cultures of one of the common strains are sometimes added about an hour after the sulfur dioxide. From 1 to 3 per cent of the pure culture is commonly used. For producing white, sweet dessert wine, with its restricted period of fermentation, there is little advantage to be obtained from using a particular strain of pure yeast. (See p. 43 for the possible effects of mixed cultures.)

After pressing, the fermentation may be conducted in closed or open containers. Closed tanks are preferable because they reduce the possibilities of contamination and overoxidation. Special control of the temperature is not ordinarily required unless the initial temperature of the must is high or the fermenters are of too great a capacity and have a low rate of heat loss. The products of fermentation at a moderate temperature (below 80° F) are considered more desirable than those of a hot fermentation, and the resulting wine is less apt to be contaminated.

When the wine reaches the appropriate Balling, it is pumped to the fortifying room.

SPECIAL PROCEDURES FOR MUSCATEL

Improvement in California muscatels can undoubtedly be brought about by the use of better varieties (see p. 36). But the extraction of the maximum muscat flavor of which the common Muscat of Alexandria variety is capable is occasionally desirable. The simplest method of increasing the muscat flavor in the wine is that of prolonging the period of fermentation on the skins. This period cannot be unduly prolonged because the must darkens when fermented on the skins, too much tannin is extracted, and there is greater possibility of bacterial spoilage in the cap.

Punching the cap down or pumping the free-run juice over will also increase the extraction of flavor. The possibility of overoxidation is likewise increased, but if the punching-down is not continued too long, it may not be serious. Leaching of the skins with the free-run juice is

a similar type of procedure. In some cases, the skins are put through a special macerating machine before the leaching. These machines (see fig. 12) roll the skin over a metal surface so that the flesh is completely pressed away from the skin.

If the additional flavor is worth a considerable amount of labor, heat treatment may be used. The free-run juice is removed from the skins and heated to above 140° F. The heated juice is then poured onto the skins and allowed to stand for several hours before pressing. The muscat flavor is increased, the pressing is easier, and the heat treatment acts as a partial pasteurization and insures a clean fermentation. The latter consideration is important, since muscat musts are traditionally difficult to ferment and quickly spoil, even during fermentation. There is some evidence, however, that the pectin and gum content is unduly increased by this procedure and the wine may be somewhat difficult to clarify. All such treatments, involving either heat or maceration of the skins, should be used with caution until comparative tests establish their influence on the flavor, the collodial condition of the resulting wines, and the difficulty of clarification.

FORTIFICATION

In the best fermentation procedures for making white sweet dessert wines, the skins are not in contact with the must for a very long period, even with muscatels. The must is therefore free of skins during most of its fermentation and has simply to be pumped to the fortifying room at the proper time.

Angelica material may be moved to the fortifying room soon after pressing, the period of fermentation depending on the degree of sweetness desired by the wine maker and on the sugar content of the grapes. Muscat and white-port musts are fermented longer before fortification. The approximate Balling to fortify musts in order to secure the proper Balling in the finished wine is given by the chart in figure 1 (p. 49). Allowance must be made for changes due to fermentation during the pumping into the fortifying room as well as during fortification and mixing. The Balling reading may drop 2° or 3° during this period, if the must is in full fermentation at a favorable temperature. Experience with plant conditions and equipment and with different gaugers' methods and speed will establish the proper degree of safety which is necessary to secure the required sugar in the finished wine.

As previously mentioned for port, it is advantageous to fill the fortification tanks always to the same level. The gauger's and wine maker's calculations of the amount of fortifying brandy necessary can then be more easily checked with the experience of previous fortifications. The

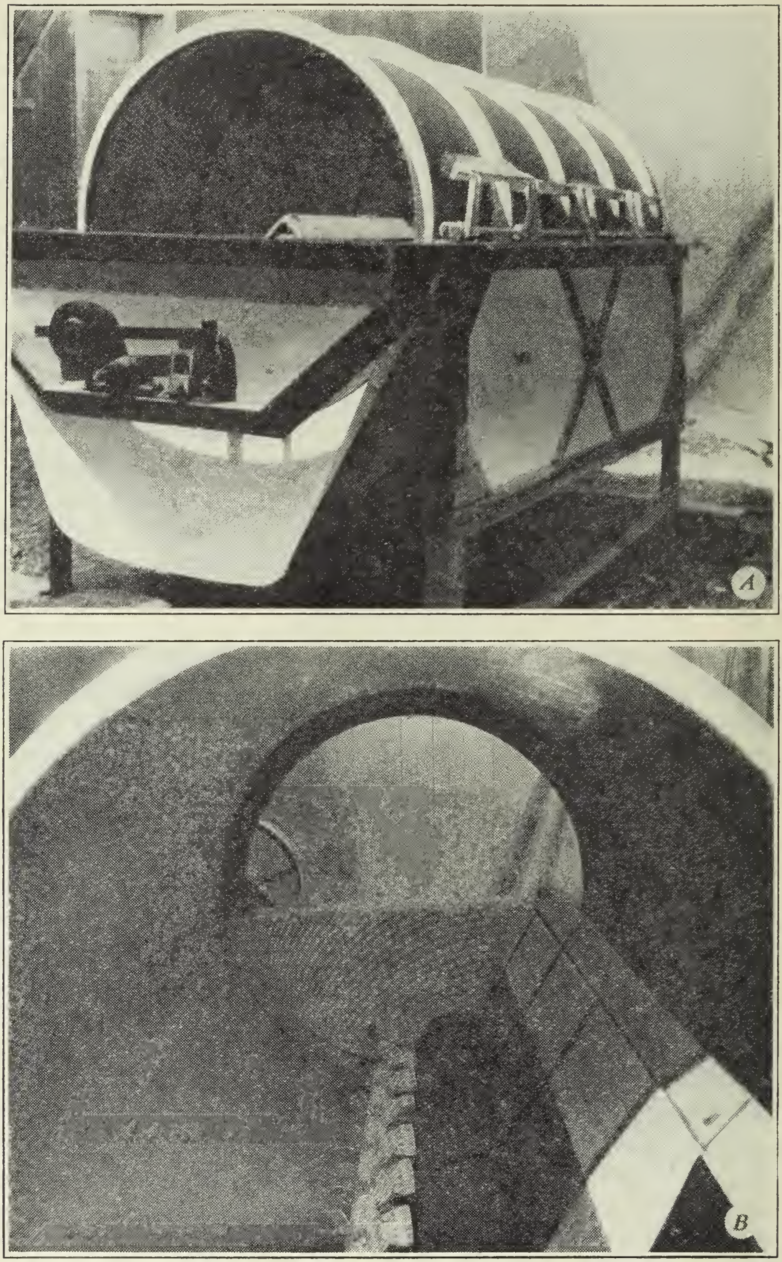

Fig. 12.—*A*, Outside view of Garolla skin macerator showing brushes which are used to keep the holes open; *B*, inside view showing the paddles to keep the pomace broken up as the outside cylinder revolves.

wine maker or his chemist should always determine the alcohol content of the fermenting must simultaneously with the gauger and should also calculate independently the amount of brandy needed. This check will prevent large and serious errors.

The required amount of fortifying brandy is then pumped into the fortifying tanks and mixed well with the must. Compressed air or pumping over are common methods of mixing.

The use of neutral fortifying brandy is recommended for Angelica and white port, but brandy made from muscat distilling material should be used in the fortification of muscatels. Fortifying brandy of 170° to 180° proof made from a fresh, dry, muscat wine has a fruity, muscat aroma and will enhance the aroma and varietal flavor of the musts which are fortified with it.

AGING

Neither Angelica nor muscatel nor California white port are aged for a long period in California. The main problem in their aging is to allow them to lose their alcoholicity and become brilliantly clear, at the same time preventing them from becoming overoxidized or developing a rancio flavor. Sufficient aging should be allowed, however, with the Angelica and muscatel to permit them to become smooth. This usually requires three or four years.

The better muscatels should receive an even longer aging. The best muscatels at Frontignan in France, which are similar to California muscatels in sugar content although somewhat lower in alcohol content (17 to 19 per cent), are frequently aged from five to ten or more years in puncheons. The time of aging will depend partially on the size of container, the type, composition, and quality of the wine, and the temperature of storage. In general, the larger the container, the better the wine, and the lower the temperature of storage, the longer the period to bring the wine to maturity. Wines of low quality, those in small containers, and those stored at high temperatures, mature more rapidly.

Racking.—The wine must usually be pumped from the fortifying room immediately. Within a week it should be racked off of the heavy yeast sediment and moved to a cool part of the cellar. Sound, clean, properly fortified dessert wines made from good healthy grapes with a clean fermentation will clarify themselves rapidly. By the first of the year or earlier, the wine will be clear and should be racked again. Periodic racking every six months is recommended for the first few years.

Filling.—Dessert wines should not be allowed to remain in unfilled containers for long periods of time. While the necessity of regular filling is not as urgent with dessert wines as with table wines, the containers should be regularly filled, particularly with the white sweet dessert

wines, where the development of large air spaces will lead to undesirable darkening of the wine. Filling every month the first six months and once between rackings thereafter is considered good practice, if barrels or puncheons are used.

Early Finishing.—With large inventories of ordinary dessert wines at the end of the vintage season, the wine maker faces the problem of disposing of those wines which will not benefit by the usual aging process. This involves the finishing of the wines for bulk shipment within the year after they are made. The commercial demand for young, cheap, ordinary-quality wines has been a problem for wineries producing dessert wines as well as for those producing table wines. Early stabilization and shipment of these wines is necessary. The whole procedure, which is recommended only for such wines, usually involves reducing the temperature to slightly below 20° F for about a week, filtering, pumping through a heat exchanger to 160° or higher, and possibly fining with bentonite and close-filtering. It is sometimes necessary to repeat the treatment to obtain permanent brightness. This type of wine is also frequently kept at a level of 50 to 100 parts per million of sulfur dioxide to prevent growth of certain organisms. (See p. 144.)

The best muscatels and Angelicas, however, are simply racked, and after a year or two stored in small containers of 54- to 200-gallon capacity. They are bottled after two to ten or more years' aging. The wine should be fined during a cool period. Wines which do not clear up by themselves should not be aged in this fashion and should be handled by the rapid-finishing methods given above.

Preparation of White Port.—The present-day California white port is made by adding from 1 to 10 pounds of one of the commercial activated carbons to 1,000 gallons of white or nearly white wine. Both "vegetable-char" and "bone-char" decolorizing carbons are used; the latter are preferred by most wine makers. The minimum quantity required to decolorize each lot of wine should be determined in the laboratory, because it varies for each wine and for each type of charcoal. To obtain a light straw-yellow wine, about 2 to 4 pounds of the newer types of activated bone charcoal per 1,000 gallons will suffice; for water-white port, from 5 to 10 pounds or over per 1,000 gallons will be required. The wine is filtered off the charcoal after several days and is usually shipped or bottled after a short period of aging, but before picking up any color.

Practically all the grape flavors and aromas are removed by this treatment, and the wine becomes practically water-white in appearance. If too much charcoal is used, the wine will take on a foreign undesirable taste: the activated carbons induce the oxidation of alcohol and result

in a rapid increase in acetaldehyde content, which may reach 300 parts per million. Furthermore, excessive use of charcoal results in formation of white deposits (see p. 149). But since the charcoal also removes off-flavors, wines having a bad odor or taste, which would otherwise be unusable, sometimes can be treated with an activated charcoal and sold as white port.

Directions for determining the minimum quantity of carbon necessary are given in booklets distributed by manufacturers.[93] Saywell[94] suggests that the wine be heated to 100° to 140° F.

Agitation of wine with the carbon is also desirable to increase the rate of decolorization. After decolorization is completed, the carbon in suspension may be removed more easily if the wine is fined with bentonite at the rate of 2 to 6 pounds per 1,000 gallons. The bentonite-treated wine is then filtered through a filter press using diatomaceous earth as a filter aid.

Gentilini[95] has found very marked differences in the decolorizing properties of Italian charcoals, and Schätzlein and Sailer[96] have found similar differences in German charcoals. In these tests, some charcoals were found to be very inferior in decolorizing properties, while others added large amounts of calcium or other ash constituents to the wine or had inferior absorption properties for pectins. No comparable study is available for commercially available American charcoals, so the wineries in this state should conduct their own tests to determine the most efficient products.

In addition, Mótusz[97] has shown that the ash content of certain activated carbons is excessively high and that metallic impurities such as iron and manganese enter the wine during their use. He recommends that the content of iron and manganese salts should not exceed 0.01 to 0.05 per cent in the activated carbons used in the winery. The possibility of pickup of excessive amounts of anions, such as phosphates, should also be borne in mind.

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[93] Anonymous. The modern purifier. 98 p. Industrial Chemical Sales Division, West Virginia Pulp and Paper Company, New York, N. Y. 1937.

Anonymous. Conditioning wines with Darco. 10 p. Darco Corporation, New York, N. Y. 1936.

Anonymous. Handbook for counter-current treatment with activated carbon. 29 p. Darco Corporation, New York, N. Y. 1939.

[94] Saywell, L. G. Use of activated carbons in wines. The Wine Review 3(9): 17–18. 1935.

[95] Gentilini, L. Di alcuni carboni in enologia. Conegliano Regia Stazione Sperimentale di Viticoltura e di Enologia Annuario 7:301–15, 317–37. 1937.

[96] Schätzlein, Chr., and E. Sailer. Die Aktivkohlen und ihre Verwendung zur Behandlung von Weinen und Süssmosten. Wein und Rebe **18**:258–65. 1937.

[97] Mótusz, J. Extractable mineral components of active carbon preparations. [Translated title.] Kisérletügyi Közlemények **38**:161–72. 1935. *Abstracted in:* Industrial and Engineering Chemistry, news edition **14**:87. 1936; *and in:* Chemical Abstracts 30:1954. 1936.

DIRECTIONS FOR MAKING SHERRY AND OTHER RANCIO-FLAVORED WINES[98]

Flavor.—Sweet white wines of low acid and tannin content, containing appreciable quantities of unfermented sugar, readily develop, on exposure to air, a peculiar characteristic taste known as "rancio" (*goût de rance* in France). This taste is produced largely as the result of the oxidative caramelization of the sugars and oxidation of other substances present. This oxidation and caramelization is not desirable in delicately flavored, fruity wines like muscatel, but when suitably controlled it is desirable in the sweet Madeira, Malaga, and Marsala types of wine. (See p. 31 and p. 108.) The sugars present in the wine may also slowly caramelize during storage, particularly at higher temperatures. The flavor developed in California sherries of commerce by suitable treatment is often, but improperly, called "sherry taste," although it is not at all analagous to the flavor of Spanish sherries. It does resemble the flavor of certain wines produced in the south of France—Banyuls, for example—and in Madeira. The excessive caramelized flavor of certain California sherries is not, however, a true rancio flavor.

The production of the proper rancio flavor requires considerable skill and care. Another feature these wines have in common is that their flavor is greatly improved by storage in oak, even at high temperatures, for they are tolerant of oak extractives. The rancio-flavored wines improve more during storage in cask, even when this is prolonged, than do other wines, and (with the possible exception of the more delicate *fino* types to be discussed later) they do not become "vapid" on exposure to air.

Acetaldehyde Production.—Oxidation of alcohol to acetaldehyde is an important factor in the production of flavor, both in Spanish sherry and rancio wines such as California sherry. Acetaldehyde is a particularly important flavoring constituent of the *fino* type of Spanish sherries, where it is present in relatively high concentrations. Trillat[99] reported the acetaldehyde content of a fifteen-year-old Jerez (Spanish sherry) wine as 276 mg per liter of free aldehyde and 418 mg per liter of total aldehyde. Rocques[100] found a Jerez wine to contain 199 mg and an amontillado type 383 mg per liter of total aldehyde. Normal table wines (both red and white) usually contain less than 50 mg per liter even when old, and the acetaldehyde flavor in them is decidedly dis-

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[98] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 173–74.

[99] Trillat, M. A. L'aldéhyde acetique dans le vin, son origine et ses effets. Institut Pasteur [Paris] Annales 22:704–19, 753–62, 876–95. 1908.

[100] Rocques, X. Le bouquet des vins. Revue de Viticulture 12:95–99. 1899.

agreeable when it reaches 100 mg per liter. Rancio-flavored dessert wines may and do contain more acetaldehyde than the table wines without becoming objectionable to taste, particularly when they also contain sufficient sulfite or other substances to combine with it. Combined acetaldehyde blends into the wine better than free.

The characteristic flavor of Marsala, Madeira, and sherry wines from Europe is obtained largely by a process of manufacture peculiar to each wine: the use of caramelized grape concentrate as a base for Marsala wine, the use of a cooked wine as a base for Madeira, and the use in Spanish sherry of a peculiar yeast capable of vigorously fermenting must in its anaerobic stage, and of forming a heavy film in its aerobic or oxidative stage. In California, on the other hand, no uniform process is used at present in making any of these types. Because of this difference, the European as well as the California practice is given in this section.

MAKING SPANISH SHERRY WINE

Types.—A number of distinctly different types of sherries are produced in and about Jerez de la Frontera in Andalusia, a province in the south of Spain. These wines are of pale or deep golden color, sweet or dry, and with an alcoholic content of 14 to 24 per cent, usually 16 to 18 per cent, and from 2 to 20 per cent of extract, averaging about 5. These Jerez (Xérèz), or sherry, wines are each of surprisingly standard and uniform market grade.[101] This standardization is obtained by a process of blending different wines and wines of different years, according to qualities acquired or not acquired with time, in a solera system of maturing. Certain of them are also subjected to heating in the sun in oak containers for varying periods of time, although this is not the case for the drier, finer, and more characteristic wines. Several of the sweet wines of Jerez, used primarily for blending, have a characteristic rancio flavor, and this has resulted in the confusion of rancio flavor with the true sherry flavor.

The basic types of sherry wine in commerce at the present time in the sherry district proper, according to González Gordon (cited in footnote 16, p. 15) are the *finos, amontillados,* and *olorosos.*

The *finos* are very light straw-colored wines having a peculiar, slightly bitter, hazelnut flavor. They are practically dry (as low in reducing sugar content as the dry table wines of commerce). They are free from a rancio flavor, but may have a slight and pleasant oaky aroma and taste.

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[101] Greenup, Julian C. The Spanish spirits and wine industry. Special report by the Acting Commercial Attache, Madrid, Spain. October 7, 1933. 20 p. (Typewritten manuscript distributed by Wine Institute.)

Daniel M. Braddock. The wines of Spain. Voluntary report of the American Vice-Consul, Barcelona, Spain. May 16, 1933. 58 p. (Typewritten manuscript distributed by Wine Institute.)

Their peculiar flavor is developed largely as a result of their secondary fermentation. In the nomenclature of the cellar foreman at Jerez, they are sometimes called *palmas*.

The *amontillados* are somewhat darker than the *finos,* being more yellow or even slightly amber. The name is derived from their resemblance to the *montilla* wines which are produced in the province of Cordova. Their character is a result of the long aging of a wine of the *finos* type. Their alcohol and extract contents are somewhat higher than those of the latter. *Vino de Pasto* is a wine of the *amontillado* type but is less dry and of lower quality.

The *olorosos* are wines of an even deeper color, a full amber. With a few exceptions, they are fairly sweet, 1 to 4 per cent sugar, and they range from 18 to over 20 per cent alcohol. The *palo cortado* is younger wine of the *oloroso* type and is said to have an aroma resembling that of an *amontillado. Amoroso* is another *oloroso* type having a mild character. *Olorosos* are sometimes called "golden" or "East India" sherries in commerce.

The *rayas* are really wines of the *oloroso* type but have a greater body, a darker color, and are not as clean (*limpio*) as a true *oloroso.* Their flavor is rich but somewhat coarse and they are mainly used for blending.

A distinctive wine of the sherry type called *manzanilla* is produced near Sanlúcar de Barrameda. It is dry, and has a pale straw color similar to that of a *fino.* The *manzanilla* aroma is delicate and characteristic. Although of fairly low alcohol content when young, *manzanillos* range up to 21 per cent or even more when aged.

Montilla is a wine resembling sherry produced in the Los Moriles district in the province of Cordova. According to González Gordon, they resemble but lack the finesse of fine *amontillados.*

All shippers of sherry do not follow the same usage with respect to these names. Some of these terms, for example, are used by the shippers as proprietary names in this country, and the wine itself may be a different type from that indicated by the label. The analytical data for the different types given in table 27 are supposed to be from reliable sources in Spain. Although the data do indicate certain differences, the real classification of the wines into types at Jerez is by means of tasting.

Fermentation.[102]—The best sherry wine is made from Palomino grapes grown on albariza soil (a very white soil containing from about 35 to 40 per cent lime). The grapes are harvested at 12.5° to 14.0° Baumé (22.6° to 25.3° Balling) and are then partly dried in the sun 24 to 48 hours on

[102] Although a number of popular accounts of the methods used in making sherry wines in Spain are available, such as that of Allen (Allen, H. W. Romance of wine. 264 p.; see p. 134–63. E. P. Dutton and Co., New York, N. Y. 1932.), there are very few authoritative descriptions, and no complete chemical and micro-

round esparto grass mats. They are lightly crushed into lagars—stone vats about 2 × 12 × 15 feet—particular care being taken to avoid extraction of tannin. Burnt *yeso,* a natural earth composed of about 90 per cent of calcium sulfate, plaster of Paris, is added to the grapes in the lagar and additional amounts to the grapes in the press (at the rate of about 2 pounds per ton of grapes or about 1⅓ pounds per 100 gallons). The calcium sulfate precipitates the tartrates as the insoluble calcium tartrate and replaces them by an equivalent amount of the rather bitter potassium sulfate according to the following equations, the reaction in a given case depending on the ratio of calcium sulfate to tartrates present:[103]

$$CaSO_4 + 2KHC_4H_4O_6 = CaC_4H_4O_6 + H_2C_4H_4O_6 + K_2SO_4.$$
$$2CaSO_4 + 2KHC_4H_4O_6 = CaC_4H_4O_6 + K_2SO_4 + H_2SO_4.$$

According to García de Angulo (quoted by González Gordon, p. 117, cited in footnote 16, p. 15) the yesoing increases the titratable acidity of the must and reduces the pH. This is said to result in cleaner fermentations and possibly also influences the organoleptic character of wine. In addition, the potassium bitartrate content is reduced so that there is less danger of tartrate precipitation later. The mineral content is increased, however. The first pressing and free-run juice is run into oak butts of 108 Imperial gallons' capacity (130 United States gallons), in which it is fermented. According to early writers, the fermentation was allowed to proceed naturally, no sulfur dioxide or pure yeast being used to control the fermentation. More recently, however, the use of sulfur dioxide has become common, and de Bobadilla[104] has shown that in Jerez the use of sulfur dioxide is desirable in musts to be used for sherry.

The initial fermentation of the other types of sherries is conducted in a similar manner. The grapes used for the dry *manzanilla* wines are picked at a slightly lower sugar content and are heaped in deeper layers during sun-drying so that less drying occurs.

Special Types.—Pedro Ximénèz (or Pedro Jimenez) is the exceed-

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biological study of the process has been published. The account here is based chiefly on the following treatises:

Castella, F. de. Sherry: its making and rearing. Victoria Department of Agriculture Journal 7:442–46, 515–28, 577–83, 621–30, 724–27. 1909.

Rocques, X. Les vins de liqueur. Le vin de Jerez. Revue de Viticulture 19: 501–5, 570–73, 594–98. 1903.

González Gordon, M. M.[a] (cited in footnote 16, p. 15).

[103] Actually only the calcium ions and tartrate ions participate in the reaction to yield the insoluble calcium tartrate; and potassium, hydrogen, sulfate, and bitartrate ions, together with residual calcium and tartrate ions, remain.

[104] Bobadilla, G. S. de. L'emploi de l'anhydride sulfureux au point de vue des qualités organoleptiques et hygiéniques des vins. Le point de vue Espagnol. V^eme Congrès International de la Vigne et du Vin. Rapports, Tome II. Oenologie, p. 80–85. Lisbon, Portugal. 1938.

TABLE 27

COMPOSITION OF VARIOUS TYPES OF SPANISH SHERRIES

Type	Alcohol	Extract	Sugar	Total acid	Volatile acid	Ash	Potassium sulfate	Volatile esters	Total esters
	volume per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Fino[a]	16.2	1.44	0.18	0.36	0.100	0.46	0.39	0.023	0.055
Amontillado[a]	18.3	2.20	0.21	.34	.126	.55	.52	.026	.064
*Oloroso** [a]	17.2	2.66	0.60	.38	.120	.57	.47	.033	.076
Oloroso[a]	19.3	2.87	0.65	.41	.100	.70	.65	.034	.076
Oloroso† [a]	20.2	6.75	3.85	.34	.087	.59	.47	—	—
Old Oloroso[a]	23.1	5.45	1.03	.52	0.200	.86	0.76	0.075	0.215
Palma‡[b]	15.7	1.65	—	.43	—	.48	—	—	—
Cortado§[b]	18.7	2.56	—	.57	—	.55	—	—	—
Raya[b]	18.7	2.81	—	0.54	—	0.49	—	—	—

* Described as being a blend.

† Called a *Palo Cortado* and slightly sweet.

‡ A *fino* type.

§ An *oloroso* type.

Sources of data:

[a] Anonymous. The Lancet Analytical Commission on Sherry: Its production, composition and character. Lancet **1898** (II):1134–40. 1898.

[b] Bascunana, L. p. 250. *In:* González Gordon. M. M.[a] Jerez-Xeres-"Scheris." 405 p. A. Padura, Jerez de la Frontera, Spain. 1935.

ingly sweet wine made from grapes of the same name harvested at 12° to 20°Baumé (about 21.6° to 36.4° Balling) and dried in the sun for a period of 10 days (*asoleo* treatment), after which treatment they may test 22° Baumé (40° Balling) or higher. The very sweet must obtained from the partially dried grapes ferments slowly and produces a very sirupy and fragrant wine. The fermentation is further restricted by addition of some fortifying brandy. Pedro Ximénèz is chiefly a blending wine used for giving dry sherries the slight amount of fruitiness required by the trade. It may also be used to mask the bitterness of the *fino*-type wines and to soften their flavor. Occasionally it is sold by itself.

Muscatel wines, and even fortified musts, are also prepared, largely for blending purposes. A small amount of these latter types is shipped to the United States for coloring whiskies.

Vino de color, or *vino de macetilla,* is made by mixing with one portion of wine, either during or before fermentation, a certain quantity of *arrope,* a thick treacly sirup obtained by boiling down another portion of the must to about one third or one fifth its original volume. After a long, slow fermentation, during which almost the whole of the sugar is converted into alcohol, and after long aging, one obtains a brown or dark-amber wine only slightly sweet, distinctly bitter, and mainly characterized by a peculiar cooked, almost burnt, flavor. When well made and very old, it develops into a colorful wine that is used in coloring the brown sherries. *Vino de color* is made also by mixing 1 part of the heavy sirup with 8 to 10 parts of fortified wine.

Treatment after Fermentation.—After fermentation for about 2 months in butts exposed to the heat of the sun, the young wines are classified, racked into fresh casks, and fortified to about 15 per cent alcohol if necessary. As a result of the variable raw material, of uncontrolled fermentation, and of chance inoculations with microörganisms of varying degrees of desirability, the young wines are very inconstant, differing in color, body, and alcohol content from one container to another. Four classes of wines are recognized by the tasters at the first tasting: *una raya, dos rayas, tres rayas,* and *quema.* The quality of the wine is marked on the barrels themselves by certain marks. At later tastings the degree of differentiation by markings becomes more refined, especially for the drier and more delicate *una raya* wine. The original marks are amended with side marks according to the degree of fineness or with cross marks according to the richness of the wine. The other wines are of less character and quality and are used for the cheaper grades, while those of the *quema,* or *parilla,* grade are usually fit only for distillation.

The two basically distinctly different types of Spanish sherry are the

fino type, whose flavor is developed largely by a special type of secondary fermentation, the so-called *flor* stage; and the *oloroso* type, which either because of formation of too much alcohol in the primary fermentation, absence of the yeast responsible for the film stage, or other deficiencies, is not subjected to the secondary fermentation. According to de Castella (cited in footnote 102, p. 93), the film does not develop on wines containing 15.5 per cent alcohol or over.

At the first racking the drier wines are fortified to a uniform standard of approximately 15 per cent alcohol, an alcoholic content sufficiently high to protect the wine from acetification yet not high enough to interfere with the development of the film. A highly rectified neutral fortifying brandy of approximately 94 per cent alcohol content is used for fortification. These wines are then allowed to undergo the secondary slow fermentation which is chiefly responsible for the development of the particular flavor of Jerez sherries. This is a slow fermentation requiring 18 to 24 months for completion. The wines are stored in oak butts so arranged as to provide for progressive fractional blending during maturation (solera system). The wine is covered with a film during its entire sojourn in a *fino* solera. Special care is taken in withdrawing wine from and replenishing the casks of a *fino* solera to disturb neither the film nor the lees. The wine undergoes a continuous evolution during its prolonged storage in wood. Since the use of special film-forming yeasts, progressive blending, and prolonged storage in wood are important features of sherry making, they will be discussed in some detail.

Spanish Sherry Yeast.—The film-forming yeast responsible for the development of *fino* sherries was assumed by most of the early observers to be a strain of *Mycoderma vini* (commonly called "flowers of wine"). De Castella, however, questioned the identity of the ordinary "flowers of wine" with the *flor* film of Jerez, since the transformations brought about by the latter are different from those of the former. In 1933, Prostrosserdow and Afrikian[105] pointed out that Frolow-Bagrew had obtained from Spanish sherries a strongly film-forming, true *Saccharomyces* yeast. These authors obtained from Armenian wines a film-forming true yeast which was similar in physiological and morphological characteristics to the strain of yeast isolated from Jerez wines. This yeast was named by them *S. cheresiensis* var. *armensiensis*. Schanderl[106] found that the yeast cultures obtained from Jerez through Niehaus of South Africa belonged to the genus *Saccharomyces* but were capable of developing in two stages: first as true fermenting yeasts producing a vigorous alcoholic

[105] Prostrosserdow, N. N., and R. Afrikian. Jerezwein in Armenien. Das Weinland 5(12):389–91. 1933.

[106] Schanderl, Hugo. Untersuchungen über sogenannte Jerez-Hefen. Wein und Rebe 18:16–25. 1936.

fermentation and forming large quantities of alcohol; then, after the fermentation had subsided, as a film on the surface of the fermented must if the alcohol concentration was not over 14 to 15 per cent and if access to air were allowed. He considers the formation of film subsequent to alcoholic fermentation as typical for all *Saccharomyces* rather than peculiar to Jerez yeasts.[107] In a subsequent report,[108] he points out that when fermentations are conducted with free access to air, after the completion of fermentation, an oxidative phase of yeast development occurs in which the alcohol formed previously is utilized as a source of energy. The film formation is considered to be a stage in the life history of even the true wine yeasts. During the oxidative stage there is developed acetaldehyde and the other flavoring constituents typical of *fino* sherries. The type of flavor produced, the rate at which it is produced, and the nature of the subsequent changes vary with the species of yeast and the type of must. Only the true Jerez yeasts produce the most stable and desirable sherry flavor. With other yeasts, the sherry flavor is formed early in the film stage and is then wholly or partially destroyed.

Hohl and Cruess (cited in footnote 49, p. 29) have studied the characteristics of the Jerez yeasts of Spain and the Château Chalon yeasts of the Arbois district of France. From over 50 pure cultures, 15 strains were selected. These were found to fall into five groups. *Pichia* species were isolated from a mixed film from Arbois, and from a sample of Spanish sherry. These readily form films and produce agreeable aromatic esters. A strain of *Saccharomyces cerevisiae* var. *ellipsoideus* (Hansen) Stelling-Dekker isolated from Arbois wine was an active fermenter which readily settled out of the wine and formed no film. Other species of *Saccharomyces* were isolated from Jerez and Arbois wines which were all rapid fermenters and which formed a more or less heavy film after the fermentation was complete. From a mixed culture of Jerez film a strain of *Hansenula saturnus* (Klöcker) Sydow and several strains of *Torulopsis dattila* (Kluyver) Lodder were obtained. These also produced heavy films on wines of low alcohol content. It is thus likely that more than one species of yeast may be responsible for the flavor production in *fino* wines.

The Jerez yeasts, which resembled closely *Saccharomyces cerevisiae* var. *ellipsoideus,* produced from 16 to 18 per cent alcohol in a 30° Balling grape concentrate. Film formation occurred in wine brought to 13–15 per cent alcohol and even at 16 per cent. The higher the alcohol

[107] González Gordon (cited in footnote 16, p. 15; see his p. 271) in 1935 reports Marcilla, a Spanish investigator, as having found that the same yeast which is responsible for the alcoholic fermentation also produces the film.

[108] Schanderl, Hugo. Die Nutzbarmachung des oxydativen Stadiums der Hefe bei der Trauben und Beerenweinbereitung, sowie in der Brennereipraxis. Vorratspflege und Lebensmittelforschung 1:456–69. 1938.

content the scantier the film and the longer the period of time elapsed before film formation was observed. Film development on wines occurred better when the Jerez-yeast inoculations were made with yeast from the film stage. The Jerez yeasts were found to be tolerant of sulfur dioxide, being able to ferment musts containing up to 300 parts per million of sulfur dioxide. In wine the film stage developed in dry white wine to which 150 parts per million of sulfur dioxide was added at time of inoculation.

The Jerez yeasts, in the oxidative film stage, oxidize alcohol to aldehyde and eventually to carbon dioxide, and they bring about a decrease in alcohol content and in acetic acid content.[109] The ability of these yeasts to reduce volatile acidity is of practical value and apparently has been employed to reduce the volatile acidity of wine intended for conversion into *fino* sherries, according to de Castella (cited in footnote 102, p. 93).

During the oxidative stage of development, the Jerez yeasts form a thick film, in which oxidation apparently occurs intercellularly. So avid are these yeasts for oxygen that they denude the wine over which they grow of its oxygen and actually create a reducing condition similar to that observed by Pasteur for *Mycoderma vini*. It is this ability that undoubtedly is partly responsible for the fact that *fino* wine may be stored under a *flor* for several years without becoming unpleasantly vapid from overoxidation. The sediment of yeast in the storage butts which undergoes autolysis under the reducing conditions set up within the body of wine also liberates flavoring constituents.

Allan[110] found that the *flor* yeasts ferment sugar at a rate comparable with that of true wine yeasts, the initial rate of fermentation, however, being somewhat slower. He showed that the yeasts utilized the residual sugar in a wine on which they were grown and that there was a critical sugar content, approximately 0.15 grams of dextrose per 100 cc, below which the film commenced to break. These yeasts at first grew vigorously on the surface of a wine containing dextrose and formed heavy, wrinkled, creamy-white films. After three months, in small flasks, the thick films began to drop and were succeeded by thin, almost transparent films. The films on wines of lowest sugar content were first to drop. The addition of ammonium phosphate to wine was without effect on the development of *flor* yeast in the wine, neither nitrogen nor phosphorus being the limiting factors under the conditions of this experiment. The wine below the film remained clear and in every case showed a marked color reduction in comparison with the control. This lightening of color

[109] Cruess, W. V., and A. Podgorny. Destruction of volatile acidity of wine by film yeast. Fruit Products Journal 17:4–5. 1937.

[110] Allan, H. M. A study of sherry flor. Australian Brewing and Wine Journal 58(10):31–33; (11):70–71. 1939.

is commonly observed in practice and apparently is due to the development of reducing conditions in the wine as result of the rapid and complete utilization of dissolved oxygen by the film.

Chaffey[111] confirmed and extended the observations of Allan in his study of a typical strain of *flor* yeast of reputed Jerez origin. The most notable change brought about in dry wine by the film growth was a reduction in sugar, volatile acid, and fixed acid with a marked lightening in color. Tests to determine whether or not alcohol was utilized were inconclusive because of extensive evaporation under the conditions used. Several factors determining film growth on wine were studied, with the following results:

1. Aeration. Laboratory and winery tests showed that some air is necessary for film development. Color reduction, loss in volatile acidity, and rate of sugar consumption are influenced by the degree of aeration. The former two are better indications of the activity of the *flor* yeasts than aldehyde content, which tends to come to a constant level varying with the wine. Excessive aeration is undesirable because it leads to large losses of wine by evaporation (at least in small-scale experiments).

2. Sugar. Film development occurred sooner and more vigorously on wines of high sugar content than on those of low sugar content, but there was no marked difference in *flor* character between wines of different initial sugar contents. The lower limit of sugar for maintenance of vigorous growth was found to be between 0.10 and 0.16 per cent dextrose.

3. Nitrogenous Matter. Total nitrogen content was not a limiting factor for growth in Australian wines and musts, and additions of ammonium phosphate failed to stimulate growth.

4. Alcohol. The alcohol tolerance of the strain used was very high, tolerances up to 16 per cent alcohol by volume being exhibited.

5. Sulfur Dioxide. The *flor* yeast can be habituated to sulfur dioxide up to fairly high levels; sulfiting of the must in conjunction with use of a pure culture of yeast to ensure clean fermentation of the original must is recommended. Addition of sulfur dioxide up to 100 parts per million to the wine which is to be converted into sherry also is recommended to prevent bacterial spoilage.

Film yeasts are used not only in Jerez but also in the Jura district of France. Certain of the Arbois wines—Château Chalon, for example—derive their distinctive character from the action of the film yeasts, yet these wines are neither fortified nor matured by the solera system.

Soleras.—The sherry of commerce is nearly always a blended wine, well-matured sound wines being used to make the various blends. To

[111] Chaffey, W. B. Some factors influencing the development and the effect of flor yeasts. Australian Brewing and Wine Journal. 58(9):33–34; (10):31–34; (11): 31–32. 1940.

obtain a more uniform or standardized blend, the constituents are especially prepared by prolonged storage in oak butts so arranged as to permit blending during aging. A solera consists of a series of butts of about 130 gallons' capacity so arranged as to allow for withdrawal and replenishment. The butts are not completely filled and contain about 112 gallons. The solera system of handling precludes the complete filling or emptying of a butt at any time. The quantity withdrawn is limited to one quarter of the contents of a butt at any one time, about 25 gallons. Care is taken in making withdrawals and additions to disturb neither the lees nor the film. The butts are arranged into three to five or more stages, withdrawals being made from the oldest stage—no. I. When old wine is siphoned out of stage I, the contents of each butt of that stage are replenished from stage II, stage II is replenished from III, and so on, the youngest being replenished with a fresh supply of the type of wine used in the solera (such as *fino,* or *oloroso*). Two withdrawals are made from the final stage during the year, at each of which the wine is moved forward throughout the whole system. A withdrawal from any given butt of an intermediate stage is not fed bodily into an adjacent butt of the next stage but is distributed evenly among all the butts of that stage to insure complete and automatic blending and complete uniformity in all the butts of any given stage. The wine withdrawn is thus an extremely complex blend and its average age would depend on the time elapsed since the establishment of the solera. No portion of the final blend of a five-stage solera would consist of wine less than five and a half years old, and it might be even older. The number of stages in a solera and the number of butts in a given stage vary markedly. This is done to permit the maintenance of a very even standard notwithstanding a variable output. The number of stages is apparently decreased or increased according to the trade demands. When demand is active the wines of earlier stages are pushed forward more rapidly. The type of wine introduced into the solera is very carefully controlled and every effort is made to introduce only wines of the same type and flavor.

The soleras are housed in the well-ventilated, above-ground bodegas of Jerez. The dry warm atmosphere enhances the development of the wine in the soleras. The chief object of the storage of *fino* wines in the soleras is to allow a more uniform production of the desirable metabolic products of the film yeasts by making use of a heavy preformed film of yeasts, which is so managed as to remain almost unchanged. In the case of *oloroso* wines, the solera system is applied because it results in automatic blending leading to a uniform product. This is also the case with *amontillado* soleras, *amontillado* being a further development of

fino wines. Only the best *finos* are aged long enough to be converted into *amontillados.*

According to de Castella (cited in footnote 102, p. 93), as the storage of the *fino* sherries in the solera is continued, there occurs a gradual increase in the alcoholic strength of wine. It finally reaches a concentration sufficient to inhibit the growth of the *flor*. The wine becomes gradually darker, at first very slowly but afterwards more rapidly, exceedingly old wines being of a deep brown color. During the first few years, the characteristic fragrant acetaldehyde taste of the *fino* is retained, but eventually it gives place to a curious "bite" or sharpness, akin to bitterness, difficult to define but well known to connoisseurs of sherry. It takes from twelve to fifteen years, from vintage, before a wine can become an *amontillado;* as the length of time after the disappearance of the *flor* increases, the *fino* character gradually disappears until the wine reaches the complete *amontillado* character. On further storage the wine becomes stronger in alcohol, darker in color, and usually distinctly bitter. At this stage the wine may be very similar to an old *oloroso* which has not "flowered."

The flavor of Spanish *fino*-type sherry is due to the variety of grapes used, to the nature of fermentation, to the metabolic products of film yeast, and to the long storage in oak butts. The yeast growing on the surface of the wine produces certain oxidative changes and forms a considerable amount of acetaldehyde. The acetaldehyde formed in the early stages of storage in the solera apparently undergoes several modifications, and the final flavor of the sherry is probably due to the products of these reactions as well as to the special esters formed during or after fermentation and the extractives obtained from the wood. Trillat (cited in footnote 99, p. 90) and others have suggested that the fragrant acetal formed by the reaction of the acetaldehyde with alcohol adds to the bouquet of the wine, that the bitter taste may be due in part to the polymerized resins formed from the aldehyde, and that some of the aldehyde combines with the anthocyanin pigments and tannins to form insoluble compounds, which settle out of the wine.

USE OF SPANISH SHERRY YEAST OUTSIDE OF SPAIN

The Jerez yeast was introduced into Australia a number of years ago by de Castella but is not widely used there as yet. It is more widely used in South Africa, where it was introduced by Niehaus.[112] Cruess has made a number of practical tests with sherry yeast in California wineries with promising results.

In South Africa.—For the preparation of an *amontillado*-type sherry

[112] Niehaus, C. J. G. South African sherries. Farming in South Africa **12**:82, 85. 1937.

in South Africa, Niehaus recommends the following procedure. The grapes are harvested at 22° to 23° Balling, crushed, and immediately pressed. Gypsum is added to the must at the rate of 4 pounds per *leaguer* (153.7 gallons) and the must is inoculated with an actively fermenting pure culture of *flor* yeast (2 to 3 gallons of culture per *leaguer*). The fermentation is controlled by cooling and by addition of small quantities of potassium metabisulfite from time to time. The must should be fermented out dry, the fermentation being completed in closed tanks. After the fermentation is over, the young wine is stored for two weeks and then racked off the lees and fortified to 16.0 or 16.5 per cent alcohol with sound, clean, neutral, fortifying brandy. After this, it is transferred into thoroughly steamed and clean pipes or sherry butts and the entire inner surface of the container inoculated with 2 gallons of the thick lees by rolling. The lees is obtained from that left in the fermenting tanks after racking. Great care is taken not to raise the alcoholic content beyond 16.5 per cent and to use only lees from wines which have undergone a sound, normal fermentation. The oak containers are then stored in a fairly cool, well-ventilated cellar. The bungholes are stoppered with a special ventilated bung. The wines are then allowed to "flower" for 15 to 18 months. When the wine has reached the desired stage of maturation under the *flor,* the wine is siphoned off the lees and stored in fresh pipes or butts for further aging.

In California.—Cruess, Weast, and Gilliland[113] prefer to use a sound, neutral, dry, white wine fortified to 15 per cent alcohol. (As an alternative procedure, the base wine may be brought to this alcoholic content by blending with a neutral dry dessert wine.) The wine is then inoculated with a pure culture of the Jerez yeast in the film stage. To further check growth of acetic acid bacteria, about 100 parts per million of sulfur dioxide is added before inoculation. After the development of an active film over the surface of the wine, they suggest that the wine be left undisturbed for a year or two until the desired *fino* flavor has developed, then drawn off, fortified to 18 per cent alcohol with very neutral fortifying brandy, and aged in oak for a moderate period. Prolonged aging may cause undesirable oxidative changes and undue darkening.

In Australia.—Cultures of the *flor* were introduced into Australia some twenty-five years ago by de Castella and are being used for the making of the better-quality sherries, generally with marked success, although many instances of failure are also known.

To obtain better results in large-scale production of pale, delicate sherries, Chaffey (cited in footnote 111, p. 99) recommends that the base wine be fortified to slightly below 16 per cent alcohol before the com-

[113] Cruess, W. V., C. Weast, and R. Gilliland. Summary of practical investigations on film yeast. Fruit Products Journal 17:229–31, 251. 1938.

pletion of the primary fermentation, so that the remaining reducing-sugar content be between 0.2 and 0.5 per cent. The persistance of the *flor* film in the Spanish *fino* soleras is believed by Chaffey to be due to periodical replenishment of sugar content by addition of young wine. To insure the minimum risk of spoilage of the wine, sulfur dioxide up to 100 parts per million should be added to the base wine, which should then be fined, coarsely filtered, and finally germproof-filtered into clean, sterile, sulfured hogsheads. The base wine should be heavily inoculated with a pure culture in the film stage. The older method of inoculating wine with *flor* by addition of *flor* lees or fermenting must, is less satisfactory: it is liable to lead to contamination. Aeration should be so controlled that the film receives all oxygen necessary for development but is not overstimulated. This is best accomplished by filling only about 90 per cent full and then closing the bunghole after inoculation so as to allow only the slight aeration around the dry bung or cellar plug. Very small and porous containers should be paraffined on the outside to reduce absorption of oxygen through the pores of the wood. The solera system of maturation is recommended in *flor* culture, for the periodic addition of new wine replenishes the sugar and activates the film.

Those desiring to produce a sherry type of wine in California by the film-yeast process should carefully consider the time and patience which are necessary, together with the many risks of spoilage involved. Care, critical and frequent tasting, and analysis of the wines during the film stage will do much to reduce losses. The sherries produced by this process are sufficiently distinctive to be specially marketed and not to lose their character by blending. The process offers real promise for the production of a new and distinctive type of dessert wine of high quality.

CALIFORNIA PROCESS OF SHERRY MAKING

Many attempts have been made to duplicate the flavor of Spanish sherries both by the use of Spanish sherry yeasts and by various processes of aging. In California the most widely used practice is that of heating the wine under conditions which result in a slight caramelization of sugar and a certain degree of oxidation.

The caramelization and oxidation necessary to the development of a rancio taste are governed by time, temperature, and access of air. The slower the oxidation and the less the caramelization, the more delicate are the flavors produced, so that it is better to store the wine in small containers in a warm cellar or to heat for several months at a moderate temperature. Contact with metal, such as iron or copper, should be avoided during the heating process, and oak containers are preferable, since they impart to the wine the necessary oak flavor.

Various Methods.—There is much variation in the type of wine used for sherry material, and in its heating and subsequent treatment, which results in a difference in the flavor and quality of the finished products. In some cases the fortified, uncooked wine, known as sherry material, or shermat, is heated, usually in large redwood tanks equipped with copper coils through which hot water or steam is circulated. In addition, the old practice of heating sherry material in a room warmed by hot air is being revived.

To improve its flavor, the baked product is best aged in oak puncheons, although sufficient oak flavor may be obtained by storing the finished sherry in oak barrels for a short period prior to marketing. Another method used to obtain oak flavor is to store sherry material for some time in untreated, white-oak barrels and to add about 5 per cent by volume of the oak extract so obtained to other sherry material, but this is considered less desirable. It is also possible to secure the oak flavor by the use of oak chips.

It has become the practice in some wineries in California to use a small amount of muscatel in sherries to improve their bouquet. Some wineries even use dry muscat wine as the base for sherries. If sufficiently distinct and different from the regular sherries, such wines should receive distinctive names.

But little attention is paid to the question of aeration; some wineries circulate the sherry material during the heating period, and others depend on the oxygen dissolved by the wine when it is racked and filled. The effect of type of wine, acidity, tannin, sulfur dioxide content, and pH of the sherry material on the rate of formation of the desired flavor, or even on the composition of the flavoring constituents, is not known.

Sherry Material, or Shermat.—To make a good sherry, it is necessary to prepare the sherry material as carefully as the finest dry white wine. Only sound, mature white grapes, preferably Palomino (see p. 38), should be used. The must should be separated from the skins and stems as soon as possible after crushing in order to obtain a wine that will age well. High tannin content is objectionable in sherry material because it retards the development of the desired rancio flavor. The minimum quantity of sulfur dioxide necessary for a clean fermentation—2 ounces of liquid sulfur dioxide per ton—should be used, and 1 to 3 per cent by volume of an active starter of pure wine yeast added to expedite fermentation. The wine for sherry material should be fermented out dry in closed containers and the fermentation kept as cool as possible. As soon as the wine is dry, it should be pumped over to the fortification room and fortified with neutral fortifying brandy to an alcoholic content of 20.5 to 20.9 per cent. Sherry is fortified higher than other dessert wines because in the process of cooking it usually loses some alcohol.

Many wine makers prefer to pump the wine from the fermenter into a storage tank and allow it to complete its fermentation and deposit some of the yeast and organic matter before fortification. The cleaner the wine is at fortification, the better the resulting sherry. Except for the high cost involved, and the possibility of spoilage, it would probably be better to age the dry wine for a year before fortification and to fortify with aged fortifying brandy.

Heating.—The sherry material is subjected to a heating process known as "baking" or "cooking" to develop the desired sherry flavor. It is best to store the sherry material for several months at least before baking and to filter or fine just before heating. The cooking process brings about a blending of the fortifying brandy and wine and produces the characteristic flavors and color. Two methods of heating may be used, external heating or internal heating through the use of various types of immersion heaters.

The best California-type sherry is produced by heating the clear, well-aged sherry material in 50-gallon oak barrels in a room maintained at about 120° F for a period of 3 to 6 months. Heating by exposure to the sun's rays was practiced at one time in the San Joaquin Valley and is still a desirable practice. The temperature in the sherry house may be maintained by a dry heating system with a slow hot-air circulation or by the use of steam coils along the walls of the room. Care must be taken to keep the hoops tight during heating.

Because of the expense of the process, particularly the high costs of handling 50-gallon oak barrels, 3,000- to 30,000-gallon redwood tanks have been substituted for the barrels in some of the larger wineries. When large tanks are used in an externally heated sherry house, the wine may be preheated by running through a pasteurizer as the tanks are filled. Heating sherry material in small tanks in a room kept at constant temperature produces sherries of lighter color and better flavor than sherries made by the use of internal heaters. There is less danger of acquiring a burnt or metallic flavor, or of development of turbidities due to formation of metallic precipitates. The flavor should be watched, however, so that it does not become too woody.

Largely because of economy, sherry material is more commonly heated by various types of internal heaters inside the tanks. Redwood tanks of about 30,000 gallons' capacity, equipped with copper heating coils are used. If heating coils are used, it is best to circulate hot water in these coils by the use of any of the several available cheap external heaters. If hot water is not used, then the steam inlet must be placed below the outlet so that the coil is virtually filled with hot water obtained by condensa-

tion of steam. The steam coils are placed at the bottom of the tank about a foot from the walls, and the convection currents that are set up are utilized to heat the entire mass of wine. A slow circulation of the sherry material by pumping over during heating in such a tank also helps to minimize local overheating and the resulting production of a burnt flavor. The temperature of the sherry is usually maintained at about 135° F.

The use of copper coils in sherry heating tanks often results in the production of metallic flavors, for the copper is dissolved in the sherry wine in the presence of air. Thorough cleaning of the surface of the coil to remove the film of copper oxide before using the coil reduces this danger. An increase of copper to an extent of 2 parts per million occurs during the cooking of sherry under the usual commercial conditions. The copper dissolved is largely precipitated during the subsequent treatment of the wine, particularly by refrigeration. Copper-nickel alloys and stainless steel are preferable to copper for the coils but are more costly. Aluminum coils may show pitting of the surface during heating. For other heating procedures see page 107.

The alcohol fumes present in sherry heating rooms or in the partly filled or recently emptied vats constitute a fire hazard. Smoking in the vicinity of these tanks should be prohibited.

Aeration.—If California sherry material is aerated excessively during baking, it rapidly becomes vapid rather than rancio in flavor. Eastern grapes such as Concord and Norton yield a sherry material that can be aerated during heating without danger of overoxidation. Such aeration, according to Ravaz[114] and Tressler,[115] results in the elimination of the "foxy" flavors of these grapes which is objectionable in sherries.[116] The lower acidity of California sherry material may be the factor that limits the extent of oxidation permissible with it.

Oxidation during baking is greatly restricted under the usual California conditions. The sherry material is not aerated and is usually not pumped over. The oxygen absorbed during the pumping into the sherry cooker and that absorbed from the air in the headspace is usually sufficient to bring about the desired degree of oxidation in the light-bodied sherry material.

In other cases where access of oxygen is restricted, periodic aeration during baking is necessary. In some wineries the sherry material is slowly circulated by a small pump during the initial heating period. In

[114] Ravaz, L. Le défoxage des producteurs directs. Montpellier École Nationale d'Agriculture Annales **17**:71–85. 1919.

[115] Anonymous. New Tressler process hastens wine production. Glass Packer **19**(7): 423–24. 1940.

[116] Tressler's process is protected by United States patents nos. 2,181,838, and 2,181,839. 1939.

filling the sherry cookers, care must be taken to allow for expansion in volume on heating. Usually about 1 foot headspace is allowed. Generally the sherry material increases in volume by 200 to 300 gallons per 10,000 gallons. The top bung should not be driven in tightly until the sherry has reached the desired temperature.

Other Procedures.—Electrical immersion heaters have been used, but most of them result in local overheating with the production of disagreeable burnt flavors.

Heating by electrolysis, which does not produce any local overheating and which can be controlled, has been more successful. In a series of comparative tests of heating by electrolysis and by baking, Joslyn (cited in footnote 74, p. 61) found increases in extract, aldehyde, and ester content and also a darkening in color by electrolytic heating. The fixed acid content decreases during electrolytic heating with a corresponding increase in pH. A marked increase in aldehyde content occurs. The oxidation-reduction potential varied in a rather erratic manner and was not related to the acetaldehyde content. This may be due to the fact that it was not determined directly on the samples immediately after they were taken. The first sample withdrawn for analysis from the sealed bottles, however, was measured for oxidation-reduction potential. The color of the samples darkened during heating by electrolysis, but the darkening was not as rapid as the increase in aldehyde content. The final samples were rather light in body when tasted. They also resembled a *fino* sherry in aroma *but not in flavor.*

The sherry heated in the winery by the usual method increased in extract content and in aldehyde content during heating, but otherwise remained practically unaltered in composition. A slight increase in color occurred. After some 50 days of heating, the acetaldehyde content was not so high in the winery-heated samples as that found for samples heated electrically for 3 days; nor was the final sample mellow, still having a raw brandy taste which was not present in the electrolytically heated sherries.

Chemical Changes.—During the heating of sherry material with coils, under commercial conditions, the total neutral esters are reported[117] to increase to a maximum after an initial decrease at the start of the cooking followed by a marked rise as the sherry cools. The aldehydes increase initially, decrease during heating, and increase on cooling. The intensity of color as measured by a photoelectric colorimeter increases but reaches a constant value several days before the baking is pronounced completed by taste.

Some wine makers use the "break" test to determine when the baking

[117] Turbovsky, M. W. Personal communication. 1941.

is done. In this test a small quantity of hot sherry material is withdrawn, allowed to cool, and then observed. If it is clear when hot and remains clear on cooling, it is judged to be through. It is safer to taste the wines periodically, for the "break" test is frequently inconclusive.

Treatment after Heating.—After baking has been completed, the sherry is allowed to cool gradually to room temperature. It is then fined and filtered and stored for further aging. The aging of baked sherries may be carried out in a warm cellar. In case difficulty is experienced in maintaining the wine clear, grape tannin at the rate of 1 pound per 1,000 gallons and sulfur dioxide at the rate of 50 to 75 parts per million may be added. A period of aging in oak markedly improves the quality of the sherry. For other treatments after heating see page 126.

To obtain the desired degree of sweetness in the sherry wine, it may be blended with Angelica before marketing. There is a tendency to market California sherry with too much sugar and too brown a color, both of which are particularly undesirable in an appetizer or a cocktail wine.

OTHER RANCIO-FLAVORED WINES

Malaga.—A number of very sweet dessert wines are produced in the province of Granada in Spain, the most widely known being the various Malagas and muscatels. The most important Malaga wine is the Pedro Ximénèz, made as is the same wine in Jerez (see p. 95). *Vino de color* is also made in Malaga.

The so-called "California Malaga" is usually produced by baking a very sweet sherry material or by the use of a sweet sherry and reduced musts.

Madeira.—The Madeira wine is made on the Portuguese-owned Atlantic island, Madeira. The Madeira wines are noted for their longevity: even wines over one hundred years old sometimes show no sign of deterioration.

The characteristic flavor of Madeira is obtained by a process of prolonged aging in wood during which the wine is frequently fortified with small quantities of brandy. The old process as described by Thudichum and Dupré[118] was as follows: The grapes were trodden and pressed lightly in primitive basket presses and the must fermented in small barrels. Brandy was usually added at the rate of from ½ to 1 gallon to the Madeira pipe (about 110 United States gallons) of must. After the first fermentation, the wine was racked from the crude lees and again mixed with a similar quantity of brandy. After about three weeks, it was racked a second time, fined, and a gallon of fortifying brandy added.

[118] Thudichum, J. L. W., and August Dupré. A treatise on the origin, nature and varieties of wine. 760 p. (See especially p. 691–94.) Macmillan and Co., London, England. 1872.

When the wine became bright, it was racked for the last time and placed in pipes for maturation. This process required about six years, during which time a considerable amount of oxygen was absorbed by the wine as a result of ullage. Before exportation, each pipe received another gallon of fortifying brandy. The brandy used for fortification was a highly flavored one distilled at 80 per cent alcohol, similar to that used for port wines and not like the neutral fortifying brandy used in Jerez. The maturation of the Madeira wine was also hastened by heat and motion such as were obtained during shipment of wine in holds of ships to the Indies, Java, or China. Such a wine after its return was sold as "travelled wine" or *vino de roda*. The heat and motion to which the wine was subjected resulted in a quicker oxidation of the extractive and astringent principles and an earlier formation of aromatic principles. Wines which were not shipped were usually placed in heated rooms and left there for some weeks or months.

In a more modern process, the freshly expressed juice is fermented in closed wooden containers. The new wine, *vinho claro,* is heated by dry heat in *estufas* or hot chambers at 100° to 160° F for the desired period of time, the lower the temperature the longer being the time of heating required. Usually about three to six months' baking is required. The young baked wine, called *estufado vinho,* is then racked and fortified with brandy so that its alcoholic content is increased, on an average, by 10 per cent. The fortified wines, *vinhos generosos,* have then to be blended among themselves and with other *vinhos generosos* of older vintages and allowed to age in oak pipes. Wines from different districts and of different vintages vary so greatly and the quantities of each type are so small that vintage Madeiras are rarely sold. Each shipper has his own types which he maintains by judicious blendings of various vintages of the wines of several districts, striving to maintain always a wine of uniform quality for each commercial type.

Very few California wineries market a wine under the type name "Madeira." Those California Madeiras that are marketed as such usually are either baked Angelicas or California sweet sherries or blends of California dry sherries with a rancio-flavored sweet wine.

Marsala.—Marsala is the best-known Italian dessert wine among the English-speaking people. It is a fortified wine resembling sherry, but is heavier-bodied, with a more pronounced rancio flavor, and is usually deeper in color.[119] Marsala was first made in the small coastal town of the same name on the west coast of Sicily by an English merchant, John Woodhouse, in an attempt to imitate Madeira, but later a special technique was developed which gave it a character of its own. It is now made

[119] Rossati, Guido. Sweet wines of Italy. California Grape Grower 15(12):6, 7. 1934.

as a fortified sweet wine containing from 20 to 21 per cent alcohol and 5 to 6 per cent sugar, and of light-straw to deep-golden color depending on whether it is prepared for the Italian or English trade. Its special flavor is due principally to the method of preparation, which consists in blending new wine with old wine, concentrated grape sirup, fortified fresh must, and sufficient fortifying brandy to give the required degree of alcohol.

According to Bioletti,[120] in the modern process of Marsala making, must concentrated over an open fire to 60° Balling, must of 50° to 55° Balling fortified to 20 to 25 per cent alcohol, old wine, and new wine fermented to 16 per cent alcohol, in the ratio of 7:4:10:78 parts by weight, respectively, are poured, in the order given, into an open vat and thoroughly mixed. After mixing, about ⅕ ounce of tannin is added and the whole transferred to casks and "pumped over" for about half an hour. The following day the mixture is pumped over for another half hour, allowed to rest for 10 days, and then fortified to the desired degree. The next day the mixture, after fortification, is again pumped over for half an hour, and two days later it is fined with defibrinated fresh oxen's blood and filtered. Citric acid is added to bring the acidity of the wine to 0.6 per cent. Twenty days after filtration, the wine is pasteurized by heating to 158° F for 5 to 6 minutes, then cooled to 95° to 104° F, to coagulate albuminoids and hasten esterification. Two days after pasteurization the wine is clarified with oxen's blood, after 8 days racked off the sediment, and after 20 to 30 days placed in cold storage at 45° F for 6 or 7 days. Aging is then completed by storage for several years in oak casks. Many local variations for producing special types of Marsala are also employed, occasionally a small amount of herb-flavored wine being used.

The California Marsalas are similar to sweet sherry and are produced by baking fortified sweet sherry material. Black grapes like Mission or red grapes like Carignane are used. The latter are pressed shortly after crushing and the must obtained aerated before fermentation to promote removal of the pink color.

Tokay.—The California Tokay wine is another sweet rancio-flavored dessert wine. The California wine is an entirely different type from the Hungarian Tokay.[121] The latter is made mainly from raisined berries of the Furmint variety. Grapes picked late in the season, after partial

[120] Bioletti, Frederic T. How Marsala wine is made. California Grape Grower 15(12):5, 17. 1934.

[121] Ghika, George de. Tokay and other Hungarian wines. California Grape Grower 15(6):10. 1934.

Taxner, C. Tokay wine making. Wines and Vines 17(6):15. 1936.

Teleki, Sigmund. Weinbau und Weinwirtschaft in Umgarn. 127 p. (See especially p. 55–58 and 86–87.) Oesterreichischer Wirtschaftsverlag, Berlin, Germany. 1937.

drying of the berries by *Botrytis cinerea,* are considered best. A very sweet must of high sugar content is obtained; after fermentation it produces a sweet wine of low alcohol content. There are several types of Tokay wine ranging in sweetness from the very sweet essence obtained in small quantities from juice which naturally separates from the harvested berries without pressing to a moderately sweet light wine of 12 per cent alcohol.

California Tokay, on the other hand, is a blend of port, sherry, and Angelica. It must not be too red in color nor have too rancio a flavor. It should contain just enough port to give it a reddish tinge and enough sherry to produce a slight amount of rancio flavor. Some wine makers prefer to bake a light-colored port stock for Tokay, but such a wine will usually have too much rancio flavor to be acceptable.

Comparison of the Types.—Although desirable sweet, rancio-flavored dessert wines are produced in California, they seldom bear much resemblance to the European wines of the same type names and frequently are entirely different in varieties and methods used. This is true not only for the baked California sherry as compared to its Spanish prototype, but also for the less important types. The use of type names such as "Marsala," "Madeira," and "Malaga" is unnecessary because the sweet rancio-flavored dessert wines now produced in California are included in the types "California sweet sherry" and "Tokay." Development of distinctively flavored California wines of this type which are worthy of unique names will do much to improve the nomenclature situation.

GRAPE CONCENTRATE AND CARAMEL SIRUP[122]

Uses.—In the amelioration and balancing of dessert wines (and even occasionally of their musts), several substances may be used. These may enhance flavor; improve color, sugar, or alcohol content; or stabilize the wine against formation of clouds or deposits. Of these, sweetening agents like grape concentrate and sugar; acids like citric, malic, or tartaric; and tannins are added during fermentation or cellar treatment to correct for the natural deficiencies in the grapes used for wine making or more commonly to adjust the composition that is unbalanced because of failure to control the fermentation closely enough. Others, like caramel sirup, are customarily added to the wine as coloring and flavoring agents. Although cane, beet, and corn sugar are permitted by the federal laws for use as sweetening agents of the must or wine prior to fortification, only grape concentrate is permitted in California. White-grape

[122] General references on this subject in addition to those given in specific footnotes are listed on p. 174–75.

concentrate is often used in sweetening port stock, as well as white-dessert-wine base. But better results for ports are obtained by using red-grape concentrate prepared from heated grapes.

Aside from their use in wineries, concentrates are occasionally used for industrial purposes. Doubtless these uses could be extended, particularly if the concentrates were produced in the best vacuum pans. In years of low-priced grapes, preparation of concentrate is considered an advantageous method of utilizing the crop. The concentrate is then used for blending in the winery or is sold to confectionaries.

GRAPE CONCENTRATE

Several types of concentrate are used in wine making, the choice depending on the type of wine to be sweetened. For fruity, natural dessert wines like the muscatel, Angelica, or port, the grape concentrate should be free from burnt flavor, of smooth taste, and made from musts of the same type of grapes as are used in the wine. Thus, for muscatel, the grape concentrate is best prepared from the pressed juice of crushed muscat grapes. To minimize the losses in flavor as a result of oxidation and scorching due to overheating, such a concentrate is best prepared by heating the juice in a vacuum pan under as high a vacuum as is practicable.

Types of Vacuum Pans.—Several types of vacuum pans[123] may be used but the best are those equipped with external tubular heat exchangers in which the must is continuously heated to about 110° F and then sprayed into an evacuated chamber, in which it is partly concentrated by evaporation and from the bottom of which it is again pumped through the preheater. Hot water, thermostatically controlled, is used in the preheater and the must circulated in as thin a film and as rapidly as possible to avoid local overheating. Multiple-effect steam ejectors are used as the most practical means of obtaining high vacuums. The juice is concentrated to about 68° Balling. At concentrations above this, there is progressive deterioration in flavor and the danger of solidification as a result of the crystallization of dextrose; at concentrations below this, the concentrate will be subject to spoilage by fermentation.[124] Stainless steel is preferred for the vacuum pan and the heating units which come in contact with the juice in order to avoid metallic contamination.

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[123] Irish, J. H. Fruit juice concentrates. California Agr. Exp. Sta. Bul. **392**:1–20. 1925. Revised 1931. (Out of print.)

Joslyn, M. A., and G. L. Marsh. Utilization of fruit in commercial production of fruit juices. California Agr. Exp. Sta. Cir. **344**:1–63. 1937.

Tressler, D. K., M. A. Joslyn, and G. L. Marsh. (Cited in footnote 83, p. 77.) (See especially p. 357–99.)

[124] Richert, P. H. Darkening and other grape products problems. Fruit Products Journal **10**:36–37, 57–58. 1930.

Procedure.—The older method[125] of making white-grape concentrate was to crush the grapes, sulfite them with 100 to 200 parts per million of sulfur dioxide and allow them to stand until the cap of skins and seeds formed and rose to the top. The free-run must was then drawn off and pumped into jacketed copper vacuum pans in which the juice was heated by steam. The juice was concentrated to about 72° Balling under a vacuum of about 27 to 28 inches obtained by a wet vacuum pump. The concentrate was run into temporary storage tanks in which it was stored for about two weeks to allow cream-of-tartar crystals and coagulated organic matter to settle out. It was then run into storage tanks in which it often solidified or deposited large amounts of dextrose hydrate crystals. This concentrate was occasionally heavily contaminated with copper and iron salts and when reconstituted into juice by addition of water gave a discolored and off-flavored juice. In the best modern procedures clear juice is obtained by cooling the must, and this clear juice is used in the best vacuum pans operated as previously described.

For fruity wines the concentrate should be free from caramelization, oxidation, and metallic contamination. Oxidation and local overheating must therefore be avoided in its manufacture. Since even the best-made concentrate deteriorates in flavor and darkens in color during storage, it must be stored in a cool place or used soon after making. The higher the degree of concentration, the more rapidly does concentrate spoil from chemical interaction of constituents—the formation of humic acids and similar substances. Freshly made concentrate should be detartrated by storage in a settling tank for a week or two before use. If it is to be stored, 5-gallon tin cans are used, although it may also be placed in barrels. This latter procedure is less satisfactory owing to the difficulty of removing the concentrate, especially after a period of storage. Concrete containers have also been used for storage.

Composition.—The usual California concentrate produced at present has a Balling of 65° to 72°. At concentrations below about 60°, fermentation by species of *Zygosaccharomyces* and other yeasts may occur. In Italy, Mensio and Tarantola[126] report widely varying Ballings for commercial concentrates—40°–70° Balling. Because of the high specific gravity (1.3–1.4), the results of concentrate analysis should be expressed on a weight basis.

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[125] Anonymous. Grape syrup. Appendix A to the annual report of the Board of State Viticultural Commissioners for 1893. p. 1–15. State Printing Office, Sacramento, Calif. 1893.

Cruess, W. V. Commercial production of grape syrup. California Agr. Exp. Sta. Bul. 321:401–16. 1920. (Out of print.)

[126] Mensio, C., and C. Tarantola. I mosti concentrati, loro composizione e loro fermenti. Regina Stazione Enologica Sperimentale di Asti Annuario (Serie II) I:243–51. 1934.

Reduced Musts.—In the preparation of California Madeira- and Marsala-type wines, a caramelized concentrate is desired. This is prepared by boiling the must down in an open, steam-jacketed kettle. During boiling the sides of the kettle should be scraped to prevent burning of the juice with the consequent production of a dark, bitter-flavored concentrate. The degree of concentration is usually less than that for concentrate produced in vacuum pans. Usually the juice is concentrated about 2:1 or 3:1. It is considered desirable to age the newly prepared reduced must before using it for blending. Aging should take place in oak barrels at room temperatures. The darkening which takes place under these conditions is not considered undesirable.

Addition to Musts.—Concentrate used to sweeten the wine may be added as such prior to fortification. After fortification it should be added to the wine as a fortified grape concentrate but this is apparently not legal under the present regulations of the United States Bureau of Internal Revenue. (See footnote 152, p. 136.)

CARAMEL SIRUP

Caramel is a brownish-colored substance obtained by heating sucrose to from 338° to 374° F for 2 or 3 hours. As ordinarily prepared it is readily soluble in water but insoluble in strong alcohol, ether, or chloroform. The solubility and coloring power depend on the temperature to which the sugar is heated and the length of heating period. During the heating, water is lost, and the solubility even in water decreases progressively as the extent of dehydration increases. At a loss of 10 per cent in weight, sucrose produces an alcohol-soluble caramel dissolving in 84 per cent alcohol; similar caramel may be obtained by extracting crude caramel with a solution containing 84 per cent alcohol. Up to a loss of 13 per cent in weight (of the original sucrose), caramel dissolves in water well and rapidly; at a loss in weight of 15 to 17 per cent it still dissolves, but more slowly. The coloring value of caramel increases with loss in weight, the more insoluble caramels having the greatest coloring power.

Caramels of improved purity may be prepared by heating sugar *in vacuo* until the desired loss in weight is obtained.

Chemical Changes.—The formation of caramel from sucrose consists primarily in the splitting off of water in successive stages, which gives rise to a series of dehydration and condensation products of varying complexity.[127] Many investigators have attempted to isolate characteristic components of caramel without convincing evidence as to their

[127] Browne, C. A. A handbook of sugar analyses. 787 + 101 p. (See especially p. 655–56.) John Wiley and Sons, New York, N. Y. 1912.

nature or as to the chemistry of the process. Schweizer,[128] Elbe,[129] and Schumaker and Buchanan[130] have reported recent investigations of such products. The most significant contribution was that of Schweizer, who showed that caramel is a mixture of isosaccharosan and humin in varying degrees depending on the extent of dehydration. Caramelization begins with the formation of isosaccharosan (after a loss in weight of about 5 per cent). On further heating it in turn is converted into humin. Sugar humin is a polymerized dehydration product of sucrose in which the hexose skeleton remains intact. Schweitzer[131] suggested that humin was formed from isosaccharosan according to the following equation:

$$nC_{12}H_8O_3 \cdot (OH)_2 \rightarrow (C_{12}H_8O_3)_n\, O_{n-1}\, (OH)_2 + n-1\, (H_2O)$$

The enormous coloring power of caramel (solutions of 1:200,000 are still easily detectable) is due to the colloidal humin fraction.

Use of Caramel Sirup.—Caramel sirup is a very black, thick, almost pasty mass which disperses readily in water. For use in wine and brandy, an alcohol-soluble caramel free from iron and copper salts is necessary. A water-soluble caramel may precipitate out of the wine or brandy on standing. Under certain conditions caramel will precipitate out of alcoholic solutions in combination with paraldehyde as a brownish-yellow, gummy precipitate. Its colloidal nature also renders it susceptible to precipitation by certain metallic salts.

DIRECTIONS FOR MAKING VERMOUTH AND RELATED PRODUCTS[132]

Vermouth is essentially a basic fortified wine blended with an infusion of a characteristic mixture of bitter and aromatic herbs. The type, quality, and quantities of herbs used, the method of preparing the extract, and the nature of the wine base used determine the quality and type of vermouth.[133] Two types of vermouth are recognized, the Italian or sweet vermouth, of from 15 to 17 per cent alcohol and 12 to 19 per cent reducing sugar; and the French or dry vermouth, of about 18 per cent alcohol and 4 per cent reducing sugar.

[128] Schweizer, A. Caramel and humin. A contribution to the knowledge of the decomposition products of sugar. Recueil des Travaux Chimiques des Pays-Bas 57: 345–82. 1938.

[129] Elbe, Guenther von. The nature of sucrose caramel. American Chemical Society Journal 58:600–1. 1936.

[130] Shumaker, John B., and J. H. Buchanan. A study of caramel color. Iowa State College Journal of Science 6:367–79. 1932.

[131] Schweitzer, A. The composition of sugar humin. Recueil des Travaux Chimiques des Pays-Bas 57:886–90. 1938.

[132] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 175.

[133] Bianchini, L. N. Vermouth. Problems confronting its manufacture in America. The Wine Review 8(12):20–21. 1940.

HISTORY IN THE UNITED STATES

Prior to Prohibition, vermouth was produced in the United States only to a limited extent, a little sweet vermouth being made with a sweet-wine base[134] by the leading wineries of California. After Repeal the demand for vermouth, principally for use in mixed drinks, increased greatly; and imports, principally from Italy and France, rose accordingly. A number of domestic firms also soon began to produce substantial quantities. United States production, however, was limited at first to rectifying plants located chiefly in the eastern states, particularly New York.

Legal Restrictions.—Prior to June, 1936, the vermouth made in the United States was subject to three taxes: (1) a tax on the wine used, at the regular wine rates; (2) a rectifier's tax of 30 cents per proof gallon; and (3) a tax on the finished product. Production in wineries was not permitted by law until 1936. Under the provisions of the Liquor Tax Administration Act of 1936, vermouth now pays only the regular withdrawal tax, if made in a bonded winery from fortified sweet wine, without the addition of additional spirits. To avoid payment of rectifier's tax and the restrictions governing rectification, distilled spirits may not be added to the fortified sweet wine used in its manufacture or to the vermouth during or after manufacture.

To meet the present restrictions on the manufacture of vermouth (see Regulations 7, p. 23, 42, 43, cited in footnote 55, p. 40), the wine base and the prepared extract of the mixed herbs are transferred to a separate vermouth department not communicating with any other department. A separate room must be used exclusively for the manufacture and storage of vermouth and for the storage of supplies necessary or incidental to the manufacture of vermouth. All fortified dessert wine transferred to the vermouth department must be used immediately in the manufacture of vermouth. The finished product may be transferred to another department of the winery for storage but must be kept separate and apart from other wines. No alcoholic extract except such as may be made by macerating herbs and other nonalcoholic flavoring materials in wine in the vermouth department may be used in the manufacture of vermouth in such a department. A formula showing the ingredients to be used, the details of the process of manufacture, and the alcoholic contents of the proposed finished product must be filed with the district supervisor of the United States Bureau of Internal Revenue.

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[134] United States Tariff Commission. Grapes, raisins, and wines. Report No. 134, 2d series. 408 p. (See especially p. 241–42.) United States Printing Office, Washington, D. C. 1939.

NATURE OF THE HERBS

According to Brévans[135] the constituents of herbs may be classified as follows: hydrocarbons (such as styrol, cymene, pinene, and various other terpenes); aldehydes (such as citral, citronellal, furfural, benzoic aldehyde, vanillin, cinnanaldehyde); ketones (such as methylheptenone, carvone, luparone, thujone); lactones (such as alantolactone); the important oxide cineole or eucalyptol; phenols and phenol derivatives (such as luparol, thymol, cadinene, and caryophyllene); alcohols, particularly terpenic alcohols (such as calamenol, citronellol, borneol, anethol, eugenol, terpineol, and safrol); alkaloids (such as quinine, cusparine, and absotin); glucosides (such as absinthin, gratiolin, quassin, aloin); saccharides (such as gentianose); tannins; coloring matters; gums; resins (such as humulon); numerous esters (such as amyl valerate); simple acids (such as citric); and complex acids (such as angelic and alantolic). The more important flavoring constituents of some of the common herbs used in vermouth production are given in table 28.

According to Garino-Canina[136] and the standard pharmaceutical works, certain of these constituents have medicinal properties—laxative and others.

SWEET (ITALIAN) VERMOUTH

Composition.—The typical Italian vermouth is the Martini and Rossi *vino vermouth* produced in Turin. This is a golden to deep-golden-yellow wine with a slight muscat flavor and a sweet, nutty, generous, warming, and well-developed fragrance and a slightly bitter and agreeable aftertaste. It contains on the average 15.2 per cent alcohol, 18 to 20 per cent reducing sugar, and 0.50 to 0.53 per cent total acid.

According to Rossati[137] the base of the best vermouth of Turin is a fortified wine, originally of the muscat type, grown in Piedmont and noted for its flavor and high sugar content. White wines of southern Italy, clearer in appearance, thinner in body, and more neutral in flavor, are used in the production of the common vermouths, which age more quickly and remain clear. In either case the wine is flavored by an alcohol extract of various herbs, those most commonly used being coriander, bitter orange peel, Roman wormwood, chincona, European centaury, calamus (sweet flag), elder flowers, angelica, orris, gentian,

[135] Brévans, J. de. La fabrication des liqueurs. 432 p. Librairie J.-B. Baillière et Fils, Paris, France. 1920.

See also description of the herbs and drugs given in: United States National Formulary, 4th ed. 394 p. American Pharmaceutical Association, Philadelphia, 1916.

[136] Garino-Canina, E. Vini aperitivi francesi. Regia Stazione Enologica Sperimentale di Asti Annuario (Serie II) I:223–33. 1934.

[137] Rossati, Guido. Sweet wines of Italy. California Grape Grower 15(6):24–25. 1934.

TABLE 28

PARTIAL LIST OF THE SUBSTANCES EXTRACTED FROM THE VARIOUS HERBS USED IN VERMOUTH MAKING

Herb or drug	Alkaloids	Glucosides	Other flavoring constituents
Aloe	——	Aloin	——
Angelica	——	?	Angelic acid, terpenes, valeric acid
Angostura	Cusparine, etc.	——	Terpenes
Anise	Demascenine	Melanthin	Anethole, safrol, methylchavicol
Benzoin	——	——	Dextrane, an oil, and benzoid acid
Bitter orange peel	——	Hesperidin, etc.	Limonene, citronellol, cymene, etc.
Calamus	——	Acorin	Choline, calamene, calamenol, etc.
Cascarilla	——	?	Cascarine, dipentene
Chincona	Quinine, etc.	——	Cinchotannic acid
Cinnamon	?	?	Eugenol, cineole, pinene, cinnamaldehyde
Clammy sage	——	——	Salirol ?, thujone
Clove	——	——	Eugenol, caryophyllenes, etc.
Coca	Cocaine	——	——
Common hyssop	——	Gratiolin, etc.	Pinochamphone, 1-pinochampheol
Coriander	——	——	α and γ terpinene, geraniol, etc.
Elecampane	——	Datiscetin	Alantolactone, alantolic acid
European centaury	——	Erythrocentaurin	——
European meadowsweet	——	Amygdalin, etc.	Salicylic aldehyde
Fennel	——	?	Fenechone, anethole, safrol, α phellandrene
Fenugreek	Trigonelline	——	——
Galingale	——	(Present)	Cineole, sylvestrene ?
Gentian	——	Gentiin, etc.	Gentisin, gentianose, tannin
Hop	——	——	Humulon, humulene, luparol, etc.
Lemon balm	——	——	Citral, citronellal
Lesser cardamon	Cusparine	?	Cineole, α terpinene
Marjoram	——	——	Carvacrol, cymene
Nutmeg	——	——	Terpenes, myristicin
Orris	——	Iridin	Irone, ionone, myristic acid
Pomegranate	Pelletierine, etc.	——	Tannins
Quassia	——	Quassin, etc.	——
Rhubarb	?	(Present)	Tannins, resins
Roman camomile	?	?	Anthemol, amyl and butyl valerate, etc.
Rosemary	——	——	Oils, pinene, borneol, etc.
Star anise	Damascenine	Melanthin	Anethole, safrol, etc.
Sweet marjoram	——	——	Terpinen-4-ol
Thyme	——	——	Thymol, cymene, pinene, etc.
Valerian	(Present)	——	Valeric acid
Vanilla	——	——	Vanillin
Wormwood	Abrotine	Absinthin	Absinthol, thujyl alcohol, thujone, etc.
Yarrow	Achilleine	——	Cineol

Sources of data:

Brévans, J. de. La fabrication des liqueurs. 568 p. Librairie J.-B. Baillière et Fils, Paris, France. 1908. 2d ed. 432 p. 1920.

Gisvold, O., and C. H. Rogers. The chemistry of plant constituents. 309 p. Burgess Publishing Co., Minneapolis, Minnesota. 1939.

Haas, P., and T. G. Hill. An introduction to the chemistry of plant products. Vol. I. 414 p. Longmans, Green and Co., London, England. 1921.

Heilbron, I. M. Dictionary of organic compounds. Vol. I. 706 p. Vol. II. 846 p. Vol. III. 943 p. Oxford University Press, New York. N. Y. 1934.

Henry, T. A. The plant alkaloids. 466 p. J. & A. Churchill, London, England. 1913.

Mayer, G. Alcalöides et glucosides. 71 p. Librairie Polytechnique Ch. Béranger, Paris, France, 1934.

Simonsen, J. L. The terpenes. Vol. I. 420 p. Vol. II. 627 p. Cambridge University Press, Cambridge, England. 1931.

Sollmann, T. A manual of pharmacology. 1,190 p. W. B. Saunders Co., Philadelphia, Pa. 1936.

Wallerstein, J. S. The rôle of hops in brewing. Wallerstein Laboratories Communications **3**(8): 45–54. 1940.

cinnamon, clove, nutmeg, and cardamon. The scientific, English, Italian, and French names of these and other herbs and the portion of the plant commonly used are listed in table 29.

According to Cotone,[138] five constituents are used in making Italian vermouth: (1) a white wine as the base; (2) sugar or grape concentrate as sweetening; (3) alcohol or neutral fortifying brandy; (4) herb extract; (5) caramel sirup for coloring. The most highly prized wine base is the very sweet Muscat of Canelli that naturally contains 2 to 5 per cent alcohol, 0.4 to 0.7 per cent acid, and 12 to 20 per cent reducing sugar. Other white wines containing 10 to 12 per cent alcohol are also used. These are adjusted by the use of white grapes or wine concentrates to 15 to 16 per cent alcohol and 10 to 15 per cent unfermented sugar. Cane sugar is the only sugar used in vermouth making. Caramel sirup is added to Italian vermouth as needed to give it the characteristic yellow to amber tint.

Method of Preparation.—The aromatic and bitter principles of the herbs and drugs used in vermouth may be extracted by suspending ground or macerated herbs directly in the wine base, or by preparing an alcoholic or water extract which is then added as a flavoring agent. Wine and brandy are the more common extractives. The extraction with wine may be made cold or hot, either by percolating the base through the herbs or merely mixing the herbs with it. Softening the herbs by steeping in hot water facilitates flavor extraction by the wine.

A more uniform vermouth is obtained by the use of extracts of the various herbs. A hot-water extract of the herbs prepared by placing them in a vat, covering with hot water, and boiling for 2 to 3 hours is used in some methods. The more volatile aromatic constituents would be lost in this case but a smoother vermouth results. Some prefer to extract the herbs completely, others only partially. The latter procedure results in smoother and quicker-aging vermouth. The nature of the aromatic principles present in the herbs and drugs, their volatility, oxidizability, and solubility should govern the particular process of extraction used.

In the more commonly used process, the herbs are mixed together and then placed in the wine base until it has absorbed the desired flavors and aroma. To facilitate extraction, the wine is stirred or pumped over once a day. The herbs are allowed to macerate in the wine base for one or two weeks. In general, about ½ to 1 ounce of mixed herbs per gallon of wine is sufficient to give the best flavor. At much higher concentrations the vermouth will be too strong in flavor. Great care must be exercised in selecting the herbs and in mixing them so that no one herb

[138] Cotone, D. A. Il vino vermouth ed suoi componenti. 446 p. Casa Editrice F. Marescalchi, Casale Monferrato, Italy. 1922.

TABLE 29

SCIENTIFIC, ENGLISH, ITALIAN, AND FRENCH NAMES AND THE PLANT PART USED, OF THE HERBS REQUIRED IN THE MAKING OF VERMOUTH AND RELATED WINES

Common commercial*	Scientific name	Italian*	French*	Portion of plant commonly used
Allspice	*Pimenta officinalis*	Pépe garofanato	Piment, toute-épice	Berry
Aloe (Socotrine)	*Aloë Perryi*†	Aloè ordinario	Aloès lucide socotrin	Plant
Angelica	*Angelica Archangelica*	Angelica	Angélique	Root (occasionally seed)
Angostura	*Cusparia angostura* (or *Galipea Cusparia ?*)	Fave tonke, angustura	Angusture	Bark
Anise	*Pimpinella Anisum* (*Anisum vulgare*)	Anace, anacio	Anis, anis vert	Seed
Benzoin, gum benzoin tree	*Styrax Benzoin*	Benzoino	Benzoin	Gum
Bitter orange	*Citrus Aurantium* var. *amara*	Arancio amaro	Orange ramer, bigaradier	Peel of fruit
Blessed thistle	*Carduus benedictus* (*Cnicus benedictus*)	Cardo beneditto	Chardon bénit	Aerial portion + seeds
Calamus, sweet flag	*Acorus calamus*	Acoro aromatico	Acore aromatique	Root
Cascarilla	*Croton eleuteria*	Cascariglia, china aromatica	Cascarille	Bark
Chincona	*Cinchona calisaia* (*C. officinalis*)	China	Quinquina	Bark
Cinnamon	*Cinnamomum zeylanicum*	Cannella aromatica, etc.	Cannellier de Ceylon	Bark
Clammy sage, common clary	*Salvia Sclarea*	Salvia sclarea. etc.	Sauge sclarée	Flowers and leaves
Clove	*Eugenia caryophillata* (*Caryophyllata aromaticus*)	Garofano	Girofle des moluques‡	Flower
Coca	*Erythroxylon Coca* (*E. peruvianum*)	Coca	Coca	Leaves
Common horehound	*Marrubium vulgare*	Marrobbio	Marrube	Aerial portion
Common hyssop	*Hyssopus officinalis*	Issopo	Hyssope	Flowering plant
Coriander	*Coriandrum sativum*	Coriandoli	Coriandre	Seed
Dittany of Crete	*Origanum Dictamnus*	Dittamo cretico, origano di Creta	Dictane de Crète	Aerial portion + flowers
Elder	*Sambucus nigra*	Sambuco	Sureau	Flowers
Elecampane, common inula	*Inula helenium*	Enula campana	Aunée	Root
European centaury	*Erythrea Centaurium*	Centaurea minore	Petite centaurée	Plant
European meadowsweet§	*Filipendula ulmaria* (*Spiraea ulmaria*)	Ulmaria	Reine des prés	Root
Fennel	*Foeniculum vulgare* (*Anetum Foeniculum*)	Finocchio	Fenouil	Seed
Fenugreek	*Trigonella Foenium-graecum*	Fieno greco	Fénugrec	Seed
Fraxinella, gasplant	*Dictamnus albus*	Dittamo	Dictame	Root
Galingale, galangal	*Alpinia officinarum*	Galanga minore.	Galanga mineur	Root
Gentian	*Gentiana lutea*	Genziana maggiore	Grand gentiane	Root
Germander	*Teucrium chamaedrys*	Camendrio, querciola	Germandrée petite chêne	Plant
Ginger	*Zingiber officinale*	Zenzero	Gingembre	Root
Hart's tongue	*Scolopendrium officinale* (*Phyllitis Scolopendrium*)	Lingua cervina	Scolopendre	Plant

Hop	*Humulus lupulus*	Luppolo	Houblon	Aerial portion + flowers
Lemon balm, common balm	*Melissa officinalis*	Melissa, cedronella	Mélisse	Flowering plant
Lesser cardamon	*Elettaria Cardamomum* (*Amomum Cardamomum*)	Cardamomo	Cardamome mineur‡	Dried fruit
Lung wort, sage of Bethlehem (?)	*Pulmonaria officinalis*	Polmonaria	Pulmonaire	Aerial portion + flowers
Lungwort lichen, lung moss	*Stycta polmonacea*	Lichene pulmonario	?	Plant (a lichen)
Marjoram	*Origanum vulgare* (*O. Creticum* ?)	Origano	Origan	Aerial portion + flowers
Masterwort, hog's fennel	*Imperatoria Ostruthium* (*Peucedanum Ostruthium*)	Imperatoria	Impératoire	Root
Nutmeg	*Myristica fragrans*	Noce moscata	Muscadier, noix muscade	Seed
Orris, Florentine iris	*Iris florentina* (*I. germanica* var. ?)	Iride fiorentina	Iris de Florence	Root
Pomegranate	*Punica granatum*	Melegrano, granato	Grenadier	Bark of root
Quassia	*Quassia amara*	Quassia, legno quassio	Quassia	Wood
Rhubarb	*Rheum officinale*	Rabarbaro	Rhubarbe	Root
Roman camomile	*Anthemis nobilis*	Camomilla odorosa	Camomille romaine	Flowers
Roman wormwood	*Artemesia pontica*	Assenzio pontico¶	Absinthe pontique, (petite absinthe)	Plant
Rosemary, old man	*Rosmarinus officinalis*	Rosmarino	Rosmarin	Flowering plant
Saffron, crocus	*Crocus sativus*	Zafferano	Safran	Portion of flower
Savory (summer)	*Satureia hortensis*	Cerea, santoreggia	Sarriette	Aerial portion of plant
Speedwell	*Vernoica officinalis*	Veronica	Véronique mâle thè d'Europa	Plant ?
Star anise	*Illicium verum* (*I. anisatum*, *I. parviflorum*)	Anacio stellato	Anis étiolé, badiane	Seed
Sweet marjoram	*Origanum majorana*	Maggiorana	Marjolaine, amaracus	Aerial portion + flowers
Thyme, garden thyme	*Thymus vulgaris*	Timo pepolino	Thym	Leaf
Valerian	*Valeriana officinalis*	Valeriana minore	Valériane, herbe aux chats	Root
Vanilla	*Vanilla planifolia* (*Epidendrum Vanilla*)	Vaniglia	Vanillier lec‡	Bean
Wormwood	*Artemesia absinthium*	Assenzio maggióre	Grande absinthe, absinthe amère	Plant
Yarrow	*Achillea nobilis* (*A. millafolium*)	Achillea	Achillée	Plant
Zedoary, setwell	*Curcuma Zedoaria*	Zeodoaria	Zedoaire	Root
?	*Boletus laricus* (*Polyporus officinalis*)	Agarico bianco	Agaric blanc	Plant

* Many local synonyms and divergent spellings have been omitted; for additional names in each language, see:
Bedevain, A. Illustrated polyglottic dictionary of plant names. 644 + 456 p. Argus and Papazian Presses, Cairo, Egypt. 1936.
Hoare, A. An Italian dictionary. 906 p. Cambridge University Press, Cambridge, England. 1925.

† *Aloë vera* and *A. feros* are other aloes which are sometimes used.

‡ Preferred.

§ Possibly same as the commercial "Queen of the Meadows" (*Eupatoreum purpureum*).

¶ Assenzio gentile is the same or a similar wormwood cultivated primarily in the Piedmont district of Italy. *Artemesia vallesiaca* (assenzio gentile alpino) is usually confused with *A. pontica*. For a discussion of the various wormwoods and their uses see:
Mattirolo, O. Sulla coltivazione e sul valore delle "Artemisie" usate nella fabbricazione dei Vermouths. Reale Accademia d'Agricoltura di Torino Annali **58**:225–77. 1915.
Balzac, F. Le artemisie dei Vermouths e dei Génépis. Reale Accademia d'Agricoltura di Torino Annali **58**:279–303. 1915.

flavor predominates over that of others. There must be a harmonious blending of the bitter with the fragrant and sweet herbs. Prolonged extraction of the herbs is undesirable because the more slowly dissolving astringent and bitter flavors from the herbs will give the wine peculiar objectionable flavors. The vermouth mixture should be tasted periodically during extraction, and at the first sign of any peculiarity the wine drawn off the herbs and filtered.

This process is used in making vermouth in Tuscany, but in Turin an alcoholic extract of herbs and drugs is preferred. Here the mixture of herbs is immersed in 85 per cent alcohol, 10 liters to 6 kg of herbs, and allowed to infuse for 8 days. The extract is then drawn off the herbs and mixed with 18 liters of fresh alcohol and 7 liters of common white wine, and the 35 liters of mixture concentrated by distillation to 18 liters. This residue in the distilling flask is cooled and allowed to stand 15 days, being stirred every day. It is used in flavoring the vermouth base at the rate of 1½ to 2 liters per hectoliter of base.

Quantities of Herbs to Use.—The quantity of herbs and drugs used in making Italian vermouth varies usually from 0.7 to 1.1 kg of mixed herbs or their equivalent of extract per hectoliter of wine base, although quantities as low as 0.4 kg and as high as 2.4 kg have been suggested (1.0 kg per hectoliter corresponds to 1.27 ounces per gallon). The number of herbs in the mixture, the kinds, and the relative proportion vary greatly. Typical formulas for the herb mixtures, in grams of each kind to be used per hectoliter of wine (26.4 gallons), are given in table 30. None of the published formulas yields a vermouth with the flavor of the imported Italian vermouth, although some of them produce palatable and flavorful products. Several prepared mixtures of plant extracts and essential oils are available for use by the neophyte. The more experienced may start with one of the formulas given in table 30 and modify it to suit the taste. The better vermouth producers abroad are very particular about the source of their herbs and the particular mixture used. For example, cinnamon (*Laurus cinnamonus*) is available from several countries, including China and Ceylon, but that of Ceylon is considered to have the finest flavor and to be the most desirable for vermouth. In a similar way qualities of chincona are available. For the best results not only the best-quality herbs but only those in good condition (age) should be used.

Because of the current European war, stocks of some herbs which are secured from Europe are certain to be low, and the prices may rise unduly. American companies should investigate the possibility of growing certain of the most necessary herbs, such as coriander and wormwood. Furthermore, the extensive flora of aromatic plants endemic to

TABLE 30

Herb Mixtures in Vermouth Recipes

Herbs	Amount used per hectoliter (100 liters) of wine base																		
	In sweet (Italian) vermouth, 15 recipes															In dry (French) vermouth, 4 recipes			
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 17	No. 18	No. 19
	grams	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
Angelica	...	5	60	12	...	6	130	60	15	44	...	30	...	6	...	.....	60	...	75
Bitter orange peel	...	115	250	...	100	50	50	250	35	...	86	58	50	50	60	1,000	350	200	75
Blessed thistle	...	...	135	...	...	...	60	125	...	...	80	...	...	...	60	300	125	200	150
Calamus	22	85	150	32	...	40	...	...	50	86	84	...	80	40	60	...	150	...	150
Chincona	...	...	150	40	400	30	100	150	...	...	...	...	80	30	500	...	...	200	...
Cinnamon	22	40	100	120	50	15	...	100	35	...	80	72	40	15	...	10	...	...	...
Clammy sage	33	...	...	...	...	...	...	...	...	60	...	60	30	...	100	...	...	...	...
Clove	22	5	50	...	20	2	...	50	15	36	42	24	20	2	...	...	...	...	...
Coriander	112	225	500	50	400	100	...	500	50	76	82	84	90	100	25	...	...	...	...
Elder	...	...	200	...	...	...	...	200	35	90	100	90	...	...	100	...	...	50	200
Elecampane	...	115	125	32	...	50	...	125	35	80	66	70	50	50	500	...	...	...	150
European centaury	...	30	135	...	...	12	...	125	40	...	...	...	40	12	60	800	150	50	150
Galingale	...	...	50	...	...	...	...	50	...	...	60	...	40	...	100	...	...	...	...
Gentian	...	115	...	32	20	50	...	...	...	...	...	...	40	50	100	...	...	...	75
Germander	...	...	125	...	...	...	...	125	10	...	...	...	80	...	100	...	50	50	150
Lesser cardamon	...	30	...	...	...	12	60	125	35	...	...	...	...	12	...	100	...	...	...
Mace	...	15	...	...	20	6	...	...	...	...	50	56	...	6	...	...	...	...	...
Marjoram	...	...	...	...	...	...	...	...	35	70	70	70	...	...	...	...	...	100	...
Nutmeg	17	...	50	8	...	...	...	50	35	...	...	80	...	...	25	10	...	...	75
Orris	...	...	250	64	...	...	...	250	10	60	36	...	...	...	...	100	...	160	...
Quassia	...	...	30	...	...	...	12	30	30	...	...	...	50	12	...	...	15	...	...
Roman wormwood	50	...	...	...	...	...	60	125	170	200	200	240	180	...	60	...	...	200	...
Saffron	...	...	...	...	...	...	...	...	1	10	2	10	2	...	...	...	...	...	...
Wormwood	56	...	125	120	...	...	...	...	...	...	...	...	...	...	...	1,000	35	200	150

Additional constituents:

No. 1, 56 grams of thyme; 167 grams sweet marjoram; 50 grams angostura; 67 grams savory.
No. 2, 15 grams allspice. Recipe calls for the peel of sweet oranges rather than bitter.
No. 6, 6 grams allspice.
No. 7, 250 grams vanilla extract; 60 grams each of speedwell, lungwort and rosemary; 20 grams rhubarb.
No. 8, 10 grams vanilla extract; 20 grams wild pomegranate.
No. 9, 32 grams cascarilla bark; 10 grams fennel seed; 25 grams lungwort; 40 grams coca; 35 grams savory.
No. 10, 16 grams anise; 50 grams lemon balm; 60 grams sweet marjoram; 76 grams masterwort; 50 grams zedoary.
No. 11, 100 grams thyme; 20 grams star anise.
No. 12, 12 grams Roman camomile; 64 grams masterwort; 80 grams hops.
No. 13, 76 grams common hyssop; 16 grams star anise; 30 grams benzol; 60 grams zedoary; 40 grams *Boletus laricus*.
No. 14, 6 grams allspice.
No. 15, 25 grams angostura; 25 grams yarrow.
No. 16, 250 grams Roman camomile; 5 grams socotrine aloe; 40 cc of an infusion of raspberries; some muscat wine or elder flowers.
No. 17, 25 grams vanilla extract; 125 grams speedwell; 50 grams rosemary; 25 grams Chinese rhubarb.
No. 18, 200 grams each of speedwell and lungwort; 24 grams Chinese rhubarb.
No. 19, 200 grams of peach pits.

Sources of data:

Bennett, H. The chemical formulary. Vol. II. 570 p. D. Van Nostrand Co., New York, N. Y. 1935.
Cotone, D. A. Il vino vermouth ed i suoi componenti. 446 p. Casa Editrice F. Marescalchi. Casale Monferrato, Italy. 1922.
Hopkins, A. A. The scientific American cyclopedia of formulas. 1,077 p. Scientific American Publishing Co., New York, N. Y. 1921.
Marescalchi, A. Manuele dell'enologo e del cantiniere. 208 p. Casa editrice F. Marescalchi, Casale Monferrato, Italy. 1933.
Sèbastian, V. Traité pratique de la préparation des vins de lune. 656 p. Coulet et Fils, Montpellier, France. 1909.

California, the United States, and the Western Hemisphere has so far been but little examined for plants suitable for substituting for Old World plants or useful as ingredients for flavoring vermouth or new types of wine.

Sweet Vermouth in California.—Angelica or muscatel wines may be used as a base. A very sweet Angelica, practically a fortified must, is very useful. This should be adjusted with added grape concentrate to the proper sugar content and with citric acid for the proper acidity. Allowance should be made for dilution when extracts of herbs are to be used. The formulas given in table 30 show that vanilla should be used with discretion, if at all, in sweet vermouths—contrary to certain American practices.

The newly made vermouth should be fined, aged in wood for a short period of time, and then bottled. Prolonged aging is not desirable because of possible loss of aroma by volatilization and oxidation. Pasteurization, refrigeration, and filtration are usually sufficient to stabilize the product, but Luckow[139] reports persistent turbidity, especially at low temperature, if certain types of wood are used, notably licorice (*Glycyrrhiza glabra*) and catechu. He recommends that if these are used they be extracted separately, diluted, cooled, allowed to settle, and then filtered before they are added to the wine base.

Other herbs may yield substances which will cloud the wine. Refrigeration to a low temperature (15° F) is recommended to start the precipitation of these substances. In Europe, fining with Spanish earths is recommended, hence bentonite should give good clarification here.

DRY (FRENCH) VERMOUTH

Composition.—The typical French dry vermouth is the highly prized product of Noilly Prat and Company produced at Marseille. This is dryer and somewhat more bitter and pungent than the Italian vermouth. A typical analysis is as follows: alcohol, 18 per cent by volume; reducing sugar, 4 per cent; total acidity, as tartaric, 0.65 grams per 100 cc; volatile acidity as acetic, 0.053 grams per 100 cc.

It is easier to prepare a vermouth similar (even if not identical) in flavor to the Italian type than to duplicate the popular Noilly Prat. Two difficulties are experienced: the choice of wine base and the selection and preparation of the proper mixture of herbs.

Wine base.—Most California wine makers prefer to use a neutral sauterne-type wine as a base. The sauterne base is prepared by fortifying one lot of California sauterne low in sulfur dioxide content to 24 per cent alcohol and then mixing this with an equal volume of the 12 to 14 per cent alcohol sauterne to obtain a base containing 18 to 18½ per cent

[139] Luckow, C. Trübung in Wermutbitter. Wein und Rebe 19:11–13. 1937.

alcohol. This base is sweetened by blending and adjusted to the desired acidity with citric acid. Better dry vermouth would be produced if a wine of higher natural acidity were used.

Preparation.—The kinds and amounts of herbs used in published French vermouth formulas are given in table 30, page 123. Under California conditions about ½ ounce herb mixture, or its equivalent of extract, per gallon of wine base is best. The lack of coriander, cinnamon, and clove, and the high amounts of wormwood in the published formulas for dry vermouth may be noted.

A water extract of the herbs is preferable for the French vermouth, although maceration in wine is widely practiced. The flavored wine base is treated as the Italian vermouth but may be aged somewhat longer in wood.

Progressive fractional blending during maturation, that is, a solera, should prove useful in developing a French-type vermouth.

OTHER HERB-FLAVORED WINES

In France a very large number of herb-flavored white and red wines, other than vermouth, are sold. The most popular of these are Byrrh and Dubonnet. They are made with wines from the south of France—wines which, in general, have low alcohol and extract contents. These wines are blended with wines containing a small amount of sugar and are fortified to about 18 per cent. The herb mixtures used vary, but chincona bark, which contains the alkaloid quinine, is a major constituent (25 grams or more per gallon). Small amounts of vanilla are also used. The flavors of cinnamon and angostura may be found in others. These wines are very popular as aperitif wines, being consumed without dilution in Europe.

Formulas for wines of a similar type for strictly medicinal purposes —such as gentian and rhubarb wines—may be found in the standard dispensatory cyclopedias.

CLARIFICATION AND STABILIZATION[140]

Wines made from the proper varieties of grapes when handled by the most approved procedures and sufficiently aged almost always reach a brilliantly clear condition without additional treatment. Clarification before bottling is necessary, however, with most wines, and this is particularly true for wines which have been aged in large containers in warm cellars; for wines which are sold without having undergone a complete aging period; and for wines which are subject to, have, or have had diseases, either bacterial or nonbacterial.

[140] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 175–76.

The purposes of clarification are to produce a wine which is sufficiently clear for consumer acceptance and which, though it may not remain entirely free of sediment, will stay clear. This latter requirement is particularly difficult when the wine must withstand extremes of heat, cold, and light over a considerable period of time. The wine maker may also wish to clarify the wine in such a fashion as to prevent fermentation or to suppress or eliminate certain organisms which might be the cause of disease. Sterilization filtration, however, is rarely used with dessert wines.

While accomplishing some or all of these objects, the aroma and flavor of the wine must be harmed as little as possible. Most treatments are therefore undesirable for the more delicate wines.

STABILIZATION

The existing demand for a brilliantly clear wine which will maintain its clearness when exposed to extremes of temperature, to light, and to air, is well recognized by the California producer. It has been necessary to produce a well-stabilized wine that will withstand exposure to the temperatures of the household refrigerators and of the hot air in the retail stores, and also exposure to the light and heat of the sun when placed in window displays. Many of the problems inherent in stabilization to such influences will be overcome as retailers and consumers begin to learn the proper methods of handling and storing wine, and when more time is given in the winery to the aging of wine. But the present demand for a clear stable product will probably never completely change to one for the more delicately flavored, less-stable old wines, which often contain considerable sediment, especially if not properly handled after leaving the winery. There is undoubtedly a place for both types in the industry.

Haziness or cloudiness and the presence of sediment indicate to many consumers a defective product. Such a wine may be fundamentally sound and of excellent quality; although cloudiness and the presence of a sediment may indicate spoilage. Clouding[141] may be due to the growth and activity of bacteria and yeasts; to the formation of insoluble metallic salts of iron, copper, calcium, or tin present in colloidal suspension, or as amorphous or crystalline deposits; to the formation and precipitation of insoluble oxidized tannins, coloring matter, or similar products; to the coagulation by heat of certain heat-coagulable substances either originally present or introduced in the process of clarification; to substances such as cream of tartar or calcium tartrate precipitated by exposure to low temperatures; and to other factors.

[141] Hall, Lloyd A. Sediment in port wine. Fruit Products Journal 13(9):270–71. 1934.

Present knowledge concerning the nature of the changes involved in the formation of unattractive cloudiness and precipitation of insoluble matters is still rather meager. Furthermore the changes involved in the aging or mellowing of wine are still inadequately understood. Consequently no completely rational procedure for the control or elimination of the undesirable changes has been evolved.

For the stabilization of common sweet wines, Brown[142] recommends that the newly made wine be racked from the lees, brought to 180° F in a continuous pasteurizer, cooled to 120° to 140° and pumped hot into

TABLE 31

Rate of Change in Cream-of-Tartar Content at 24° F (–3.90° C) in Four Wine Types

Storage period	Cream-of-tartar content			
	In dry white wine	In dry red wine	In sherry material	In port
days	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*	*grams per 100 cc*
0	0.337	0.320	0.207	0.234
1	.250	.294	.182	.224
3	.200	.257	.153	.212
6	.168	.219	—	—
7	—	—	.140	.177
12	.144	.184	—	—
14	—	—	.119	.153
28	0.134	.175	.104	.143
56	—	—	.085	0.108
76	—	0.157	—	—
231	—	—	0.041	—

Source of data:

Marsh, G. L., and M. A. Joslyn. Precipitation rate of cream of tartar from wine. Industrial and Engineering Chemistry, industrial edition. **27**:1252–56. 1935.

a storage tank. A predetermined amount of bentonite is added (see p. 132) and the wine allowed to cool and become clear. The wine is then filtered, after which it is refrigerated to below 20° and stored cold for about a week to a month and then filtered again. The early heating tends to destroy the protective colloids which prevent adequate fining. The addition of tannin at the rate of 1 pound per 1,000 gallons stabilizes the white wines against later clouding and may even improve color retention of red wines lacking in tannin. Removal of excess metallic impurities or prevention of formation of metallic hazes by adjustment of acidity of the wine or by other means is also useful in stabilizing wines.

Removal of Cream of Tartar.—As may be seen from the data on cream-of-tartar content given in table 31, the rate of cream-of-tartar deposition

[142] Brown, E. M. Stabilization of Wines. Wines and Vines **17**(8):12–13. 1936.

during refrigeration is slower in dessert wines than in table wines, even though at their higher alcohol and extract content the solubility of cream of tartar would be expected to be lower than and the degree of super saturation to be greater than for table wine. The rate of precipitation of cream of tartar from the dry red wine is slower than from the dry white wine. The same difference between white and red wines is shown in the behavior of sherry and port, the rate of precipitation of cream of tartar from the port being slower, largely owing to an initial lag, than from the sherry material. It is surprising that the presence of appreciable tannin and coloring matter in dry red wine and in the port and their higher sugar and extract content would result in a lower rate of cream-of-tartar separation than occurred in dry white wine and sherry material, respectively. No significant difference in the salt and acid content between the red and white wines is to be expected; such differences in the amounts of these and other constituents as are found in red wines as compared with white ones would tend to decrease the solubility of cream of tartar in the former.

It might seem that the presence of tannin and coloring matter in the red wine may have interfered with either the formation of nuclei or the growth of crystals of cream of tartar, since the higher sugar and extract content would have the opposite effect. That the coloring matter does not have a simple retarding effect on the rate of cream-of-tartar separation —that, on the contrary, it may actually increase the rate of tartrate precipitation—was shown in an interesting experience with a California port wine.

About 8 liters of port had been stored at room temperature in a 20-liter carboy for about 8 months. This wine was found to be extremely cloudy and to have precipitated most of its coloring matter and a portion of its cream of tartar. On warming the wine at 140° F for an hour or two, the cream of tartar redissolved but the precipitated coloring matter did not, being apparently converted to an insoluble oxidized form. The surprising finding was that no cream of tartar separated from a sample of the wine when frozen under conditions such that an appreciable amount of cream of tartar precipitated in the original port. After removal of readily oxidizable coloring material, the rate of precipitation of cream of tartar and the amount precipitated were both markedly less than in the original sample, even though the cream-of-tartar content was the same. The chief changes in composition of wine during refrigeration were decreases in specific gravity, in extract, and in ash which accompanied the removal of cream of tartar and were probably caused by it. A slight increase in pH noted was also probably caused by it. In filtered new white wines the precipitate was practically

pure cream of tartar, but in red wine, coloring matter and tannin also are precipitated, particularly on freezing.

Little or no precipitation of coloring matter occurs during storage at 32° F or above *in the absence of oxidation.*

FILTRATION

Pumping or allowing wine to flow through some media of small pore size—that is, filtration—is one of the oldest and commonest methods of removing particles from wine. For dessert wines it is also one of the most satisfactory. The process is relatively rapid, does not require undue technical skill, and the results are immediate. In addition, it is a very adaptable method of clarification. It may be used for very cloudy young wines containing large amounts of yeast and colloidal material, as well as for nearly brilliant wines ready to be shipped.

Types.—There are two general types of filter processes adapted for use with wines: those which remove particles by adsorption and those which remove particles by virtue of the small pore size of the filtering surface. Filtration by adsorption is utilized in the cellulose type of filters, although there is also a certain amount of filtration due to small pore size. Filtration through material of small pore size is more common and is found in candle filters, in asbestos pad or mat filters, in filters using filter aids, and the like. In general, the latter types are used in California for cloudy young wines and even for polishing filtration of finished wines. The adsorption type of filter is mainly applicable to liquids that have only a small amount of cloudiness, although sometimes fairly cloudy wines are used. The pulp must be thoroughly sterilized before re-use.

For wines very much charged with foreign material, a filter with a very large surface is needed for efficient operation. This large surface is achieved by a very large area of filtering surface and also by mixing various filter aids in the wine during filtration. The purpose of these filter aids is to improve the rate of filtration by continually forming new and more rigid filter surfaces. The slimy or colloidal substances are thus unable to collect and form a poor filtering surface. Diatomaceous earths are the most common filter aids.[143]

The several types of commercial filters have been discussed in Bulletin 639 (p. 94–97). The metal portions of all types of filters should be constructed of corrosion-resistant materials. Filter presses are the most popular and generally useful type. In them canvas sheets are precoated with diatomaceous-earth filter aid and the wine is continually mixed with the filter aid to maintain the rate of flow. The canvas sheets must

[143] Calvert, R. Diatomaceous earth. 251 p. The Chemical Catalog Co., New York, N. Y. 1930.

be thoroughly sterilized before re-use. These presses can be purchased in a variety of sizes.

Leaf-type filters in which hollow perforated screens are coated with a filter aid are also used. The wine, mixed with filter aid, is forced through the filter surface and screen. At the finish of a run, by a suitable arrangement of the pumps, the direction of flow may be reversed and the coating removed from the screens. These filters are also available in a variety of sizes. The hollow screens are rather expensive and are somewhat difficult to clean.

The polishing filters have a small pore size: if used for cloudy liquids they will give only a small rate of flow, and much time will be lost in changing the pads or washing the candle filters; hence they should only be used for relatively clear wines. Asbestos- or fiber-pad filters are the most common. The pads must be thoroughly washed with water before use or they will give an undesirable filter taste to the wine. It is also advisable to wash the pads with a 1 per cent solution of citric or tartaric acid before use to remove soluble metallic impurities. These pads are rather expensive and are somewhat difficult to wash and sterilize for re-use. They must, therefore, usually be discarded after the filtration. Recently, new filter-pad materials made of glass, rubber, wire, and resin have been introduced.[144] The cloths made of vinyl resin yarns are resistant to acids, though not to heat, and may prove useful for wines. Some of the rubber-pad materials may also prove useful, if they communicate no taste to the wine.

Candle filters made of porcelain or carbon are occasionally used in wineries. In some cases the filter is large and as many as 20 filters may be used. For efficient use, however, nearly brilliant wine must be used.

In operating any type of filter, some test of the efficacy of the filtration should be made. Visual inspection of the original sample and the filtered wine is sometimes useful, but more adequate control is desirable. Modern industrial plants usually test the brightness of the material being filtered at successive stages of the filtration. Any convenient nephelometer system, such as a photoelectric colorimeter, may be used for this purpose.

Wines sometimes foam during routine winery handling, particularly during filtering or bottling. Removal of the foam during fermentation will help reduce foaminess in wines. New wines foam much more than old.

FINING

The use of various agents, such as milk, egg white, and blood, for facilitating the rate of sedimentation of suspended material in wine

[144] Van Antwerpen, F. J. Filter media. Industrial and Engineering Chemistry, industrial edition 32(12):1580–84. 1940.

is very ancient. In modern times these have been largely replaced with agents such as gelatin, albumin, isinglass, casein, Spanish clays, kaolin, and bentonite, as well as various European proprietary products, such as "Saf" and "Coagol." For California dessert wines, gelatin and bentonite are the only fining materials that are commonly being used for clarification.

Gelatin.—In the use of gelatin, there is a coagulation of the fining agent as soon as it is added to the wine. This is due to the chemical combination of gelatin and tannin and also to the influence of the metals of the wine on the colloid. Coagulation is particularly apt to occur if the wine has been aerated prior to or during fining, and if ferric ion is present. It is sometimes noted that wines after heating do not readily fine with gelatin. Ribéreau-Gayon and Peynaud[145] found that this failure of the gelatin to settle was due to the protective colloids present in the wine and that the effect of these protective colloids is considerably increased by heating.

Only the smallest amount of gelatin that will clarify the wine should be used. In general, the higher the tannin content and the lower the temperature, the less the amount of gelatin needed. In order to prevent overfining, small-scale laboratory tests should always be conducted with various gelatin-tannin combinations before using them in the winery. The laboratory test must be conducted at the temperature of the winery, if comparable results are to be obtained. Such tests are particularly necessary for white dessert wines, such as Angelica, which are very low in tannin. Indeed, it is questionable if gelatin should ever be used for these wines under most California dessert-winery conditions. The high storage temperatures, the very large containers, and the lack of aeration in such containers make the use of gelatin hazardous for white dessert wines. In any event, it should never be used without preliminary trials. It has also been suggested that the difference in temperature between the top and bottom of very large tanks sets up currents in the wine which continually keep the coagulated agent in suspension or at least prevent perfect settling. Whenever fining agents are used, they should be mixed with the whole mass of wine *immediately* after their introduction.

Bentonite.—Bentonite, a clay, is commonly used in California for fining dessert wines. Clay materials that are somewhat similar chemically and physically, called kaolin and Spanish earth, have been used for many years in Europe for wines which are difficult to clarify, and particularly for the sweet wines of Spain and Portugal, according to

[145] Ribéreau-Gayon, J., and E. Peynaud. Études sur le collage des vins. Revue de Viticulture 81:5–11, 37–44, 53–59, 117–24, 165–71, 201–5, 310–15, 341–46, 361–65, 389–97, 405–11, 1934; 82:8–13, 1935.

Sannino.[146] Kaolin is a clay of well-known composition, but the properties of the Spanish earths (such as those of Lebrija) are not sufficiently well known, and the analysis published by Sannino shows considerable variation, with some carbonate being present. Müller[147] also reports that Spanish earth is an impure fine clay (mainly aluminum silicate) and that it is used for the fining of wines of high specific gravity or, in Germany, in conjunction with gelatin for fining wines of highly mucilaginous nature. The amounts recommended, 100 to 400 parts per million, are similar to those recommended in California for bentonite. Ribéreau-Gayon and Peynaud recommend kaolin for wines which have been overfined with gelatin.

According to Dana and Ford,[148] bentonite occurs widely distributed in western United States and Canada, is derived from the alteration of volcanic ash or tuff, and is largely composed of montmorillonite. Montmorillonite is one of the kaolin group of silicates, possibly having the formula $(Mg, Ca) \cdot Al_2O_3 \cdot 5\ SiO_2 \cdot n\ H_2O$, with n varying from 5 to 7. The bentonite commonly used for California wines comes mainly from Wyoming. According to Müller, the absorption ability of kaolin clays for the color, aroma, and taste components of wines depends on the fineness of the clay and on the nature of the particular clay used. Bentonite has the advantage of settling quickly and of not causing cloudiness when used in excessive amounts. It should not, however, be used in amounts exceeding 700 parts per million.[149]

The earthy taste sometimes found in wines treated with clays can be removed, according to Ribéreau-Gayon,[150] by the use of a small amount of activated carbon.

Other Fining Agents.—Casein is sometimes used for fining dessert wines, particularly in conjunction with bentonite or for wines that are high in iron. Laboratory tests should be conducted on the wines in order to determine the proper amounts to use. Only good-quality casein should be used.

Fresh defibrinated blood of cows has been used but is not considered desirable because of the possible health hazards and danger of unpleasant publicity.

Fining versus Filtration.—Both fining and filtration have their ad-

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[146] Sannino, F. A. Trattato completo di enologia. 2d ed. Vol. II. 368 p. (See especially p. 95–101.) Vincenzo Bona, Torino, Italy. 1920.

[147] Müller, K. Weinbau-Lexikon, 1015 p. Paul Parey, Berlin, Germany. 1930.

[148] Dana, E. S., and W. E. Ford. A textbook of mineralogy. 4th ed. 851 p. John Wiley and Sons, New York, N. Y. 1932.

[149] Saywell, L. G. Clarification of wine. Industrial and Engineering Chemistry, industrial edition 26:981–82. 1934. (*See also:* California Wine Review 3(1):14–15, 24. 1935.)

[150] Ribéreau-Gayon, J. Clarification des vins. Revue de Viticulture 82:367–68. 1935.

vocates, and in dessert-wine making both are usually necessary. Filters are more expensive than fining agents but require little special technical training to operate. Fining agents, on the other hand, must be used with care, particularly as to the amounts and the temperatures at which they are applied. The fining agents are generally more efficacious in producing a permanently brilliant wine when properly used, but filtration is a more rapid process and can be used at any time during the year. The aeration resulting from filtration is usually beneficial in dessert wines in contrast to the effect on table wines, although undue filtration of delicate, aged dessert wines may be harmful. While filtration is undoubtedly of very great importance, the use of the various fining agents should be more generally investigated by the wineries producing dessert wines.

CENTRIFUGING

Centrifuging is more common for California dessert wines than for table wines. The wine sometimes benefits from the aeration received, and some colloidal material, not easily filtered out, may be removed. The equipment is somewhat expensive, however, and centrifuging is not as generally used in the winery as filtration.

PASTEURIZATION

Table wines are pasteurized to destroy microörganisms which are capable of producing disease in them, but dessert wines are seldom pasteurized for this purpose except for wines that are very high in microbiological content, for those that are low in alcohol content, or for those that are most subject to contamination. They may be heated, however, for the purpose of assisting the clarification.

Some forms of colloidal material are coagulated by heat treatment, but others may be permanently dispersed by pasteurization. For this reason it is better to heat only wines that are free of suspended material. The pasteurization, by its precipitation of some material, favorably aids the permanent clarification of certain dessert wines. A laboratory test should be made to determine if pasteurization will cause the precipitation of organic material. A heat exchanger in which flash pasteurization is possible is the usual means of accomplishing pasteurization. It should be constructed of corrosion-resistant metal throughout. Copper particularly should be avoided. A short period, a high temperature, and a continuous unit in which the wine is rapidly cooled is considered better than a long period, or a lower temperature, or a discontinuous type of heating. Heating to 180° F for 1 minute is the usual California practice.

PREPARATION FOR MARKETING[151]

BLENDING

Blending is one of the most important operations in the winery producing dessert wines. When properly conducted it is of great value to the winery; but when it is improperly carried out, good wines may be spoiled.

Purpose.—The purposes of blending are: (*a*) to maintain standard types, (*b*) to add to the character and bouquet of aged wines the freshness of young wines, and vice versa, (*c*) to balance the composition of wines, and (*d*) to maintain a constant supply of aging wine of a certain character. Far too little attention has been paid to the constructive values of blending in many post-Repeal plants. The very large tanks and the lack of aged stocks have, of course, greatly restricted the possibilities of blending or even made it impossible. Owing to this lack of suitable blends, some distributors have been doing their own blending.

Many of the European dessert wines owe much of their excellence to skillful handling and especially to blending after fermentation. European practice therefore includes partial fortification at fermenting rooms adjacent to the vineyard prior to, during, or immediately after fermentation and then shipment to the large central storage cellars. The wines arrive at the storage cellars with greatly varying degrees of alcohol and sugar, and often, in the case of ports particularly, are made from different mixtures of grapes. They are, however, immediately blended and refortified to make a few uniform products. They are then stored in butts or pipes of oak or in other small oak containers. Sometimes these are so arranged as to provide for progressive fractional blending during maturation (solera system, see p. 100). The wines withdrawn for shipment are then further blended to suit the trade. These procedures allow the marketing of standardized types of sweet wines from year to year, even though the wines of any given year may differ appreciably from those of other years.

Blending wines as they age, as in the solera system in Spain, is, however, an expensive system, as very large stocks must be maintained, and it has been very little practiced in this state. The system not only demands large stocks, but it is expensive to maintain owing to the large number of casks to be filled and refilled. This system or a modification of it might, however, prove useful in California for dessert wines even with large-sized containers. To set up such a blending system, a cask or tank of the best wine should be set aside. About every six months

[151] General references on this subject in addition to those given in specific footnotes in the section are listed on page 176.

or year after this wine matures about a fourth of the cask or tank should be drawn off. The secret of the success of the system lies in finding a very similar wine to refill the original container. This second container is in turn filled up with some younger but similar wine, and so on, so that eventually there may be from four to ten stages. The constant blending and the fact that only from a fourth to a half of any single cask is drawn off at one time leads to the production of a standard type which varies only slightly over a period of years. The greatest difficulty, however, is to get wines whose character and composition closely resemble those of the original type of wine for the filling of subsequent casks and not to draw on the casks too frequently or for too great a percentage of the wine.

The most important functions of blending dessert wines are to obtain standard types and maintain an identical character for them over long periods of time. The continual change in the character of the wine bottled as a certain type and brand is undesirable for it may lead to unfavorable consumer prejudice. This is particularly true for the more experienced clients who become familiar with a certain company's California port under a given label and who can, and will, detect changes in the wines of different seasons unless careful blending is practiced. The types and brands which a company may prepare for sale will depend on the stocks available as well as on the consumer's demands. Accurate records of the composition, particularly of the alcohol, total acid, sugar, and hue and depth of color, should be maintained for each type. Bottled wines should also be kept for future organoleptic (smelling, tasting, and visual) comparison.

In blending, a small proportion of aged wine, particularly that aged in small oak casks, will frequently add just the desired cachet to the wine. Some aged wines, on the other hand, lack the light color of a young Angelica or the fruity muscat flavor of a young muscatel. Blending in of younger wine is a means of improving such wines. Many wines lack a single ingredient or contain an excess of some ingredient. Proper blending will correct for these deficiencies or excesses—sugar and color are the commonest. The winery should always prepare some wine of higher and lower sugar and alcohol content than the normal to correct for such accidental discrepancies or to assist in preparing wines of any desired composition for a particular market. The alcohol content is occasionally adjusted by refortification. Refortification, however, can be done only in certain special cases and under government regulations.

The sugar content of wines may similarly be adjusted either by the addition of sweetening agents prior to fortification or by blending wines of higher sugar content with those of lower sugar content. Grape

concentrate is the only sweetening agent that can be used in ameliorating California wines. This may be used in either or both of two ways. It may be added to the wine before fortification to raise its sugar content to the desired point, or a medium-sweet concentrate containing ½ of 1 per cent of alcohol by volume may be fortified to an alcoholic content of up to 24 per cent and blended with the newly fortified wine. The latter procedure is preferred because it yields wines that are smoother in flavor.[152] Sweetened blending wines obtained by adding must or concentrate to wine and then fortifying it with brandy are used also.

The acid content of the wines should be adjusted before aging and preferably before fermentation. (See p. 44 of this bulletin and p. 35–37 of Bulletin 639.) Tannin may be added not only for stabilizing wines but also to obtain wines of better balance.

Blending out off-flavors or high volatile acidity is a dangerous practice. It is much better to dispose of wines having these defects at a minimum price rather than to spoil or impair the quality of good wine by blending and then receive only a low price for the whole blend.

Technique.—Successful blending is not easy. It requires a keen memory for small differences in odor and flavor and a clear and fixed initial idea of the type of wine that is wanted. As mentioned, comparative samples of previous blends are useful. The cost per gallon of each wine in the cellar should be known. Only those wines which are available (because of price, quantity, or other considerations) should be tasted. The previous tasting records and a copy of a recent analysis of the wine should also be available.

Trial blends are conveniently made in large, graduate cylinders, in calibrated tasting glasses, or with pipettes. After deciding on the proper proportions for a blend, a new blend with the desired percentages is made. If this test is still favorable, a trial blend of 10 to 50 gallons should be made, and stability tests conducted in the wood and in bottles at various temperatures.

After making blends, the blended wines should be allowed to age in the cask or tank from three weeks to six months before bottling, to permit any cloudiness developed by the blending to be detected and removed.

In blending wines to obtain a desired standard, the relative quantities of the wines to be used may be calculated if the composition of the components of the blend is known. If only one constituent—sugar,

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[152] A ruling of the United States Bureau of Internal Revenue requires that concentrate *per se* may be added to wine only prior to fortification. Grape products testing up to about 40.0° Balling after fortification, however, may be used in blending. Such products are classified as wine for blending purposes only.

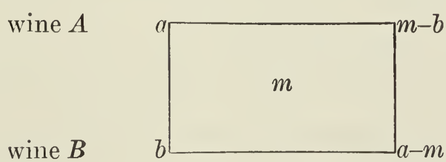
alcohol, or acid—is changed while the others remain constant, the blending formula is simple and readily applied. If more than one constituent is changed, then by adjusting first the alcohol content, then the sugar content, and so forth, the actual case may be made to approximate the theoretical. (More complicated formulas containing more than one unknown may of course be used.)

If A and B are the weights of two ingredients to be mixed to produce a weight of $(A+B)$ of the mixture, and a and b are the percentages by weight in the two ingredients of some component common to both of them and if m is the percentage of the same component in the final mixture, then it can be shown that the proportion by weight in which the ingredients must be mixed to yield a product of the desired composition is: $\frac{A}{B}=\frac{m-b}{a--m}$

If a, b, and m are percentages by volume—of alcohol, for example—and if the changes in volume that occur on mixing are neglected, then this is also the proportion by volume in which the two wines are to be mixed. For example, if the alcoholic content of wine A is 21.0 per cent, and that of wine B 19.5 per cent, and a blend containing 20.0 per cent is desired, then the proportion by volume in which A and B are to be mixed is very closely: $\frac{A}{B}=\frac{20-19.5}{21-20.0}=\frac{0.5}{1.0}=\frac{1}{2}$.

If a, b, and m are percentages by weight—of sugar, for example—and if the changes in volume that occur on mixing are neglected, and the specific gravities of the components assumed to be close enough to be the same, then the ratio by volume in which the two wines are to be mixed also is given by the above relation. For example, if the reducing-sugar content of a sherry A is 4.0 per cent and of a sherry B is 0.5 per cent, and a blend containing 2.0 per cent is desired, then the proportion by volume in which A and B are to be mixed is approximately $\frac{A}{B}=\frac{2.0-0.5}{4.0-2.0}=\frac{1.5}{2.0}=\frac{3}{4}$.

This algebraic formula may be more easily depicted by the Pearson square as follows:



If a fairly dry muscat wine testing 2° Balling is blended with a fortified unfermented muscat juice testing 20° Balling, the proportion in

which the two must be mixed to obtain a muscat testing 8° is approximately

$$\begin{array}{ccc} 20 & & 6 \\ & 8 & \\ 2 & & 12 \end{array}$$

or 6 parts of juice to 12 parts of the dry muscat wine, or 1:2.

The Balling degree, however, does not indicate the true solids content of a wine, as discussed in the section on vinification (p. 45). If the wines in the example given all contained 20.0 per cent alcohol by volume, then the sugar content on an alcohol-free basis would correspond to 8.09 per cent and 25.30 per cent for the two components of the blend and 13.93 per cent for the mixture. The proportion in which the components should be mixed would be 5.84 parts of the juice to 11.37 parts of dry wine, or 1:1.92 instead of 1:2. If the alcoholic contents of the components of the blend were different, the error introduced would be considerably greater.

TASTING

As outlined in the previous section, intelligent blending can be accomplished at the present time only on the basis of a thorough examination by smelling and tasting. Tasting is particularly important with dessert wines in which, by blending, the maintenance of a standard from year to year is attempted.

The tasting should be done in a special room which has sufficient light and is free from winery odors. A supply of cool and of warm, clean, soft water should be provided.

The best glasses for tasting are the tulip-shaped thin-walled types (see Bulletin 639, p. 105). After use they should be thoroughly washed so that no odor or flavor carries over to the next wine.

When samples are being taken directly from containers, the taster should assure himself that the wine thief used for taking the samples is clean. The thief should be sufficiently long to secure the sample well down in the container.

In examining the color of dessert wines, the standards commonly accepted by the wine industry and particularly those used by the particular winery must be considered. Visual examination and comparison with previous samples is valuable, if only an approximate duplication is desired. For more complete color specification, see page 161. A brownish tinge is not an infallible indication of age in California, where dessert wines are frequently heated. A tawny color accompanied by a clean, noncaramelized, aged aroma is desirable in ports. Some producers secure a tawny color by heating, but the aroma and flavor of such wines is not the same nor as desirable as that of the normally aged wines.

California pale sherrys should be produced naturally from light-colored wines. The regular sherry has a medium-amber color. Muscatel and Angelica should have a light-gold color. California Tokay should be a medium amber with a tinge of red.

Excessive cloudiness in dessert wines is objectionable, but the presence of small amounts of precipitate due to aging are entirely normal in dessert wines which are aged in bottles and may be found after a period of time in the bottle even from wines which have been "finished" before bottling by the most thorough treatments.

The aroma and bouquet of dessert wines are particularly important. The quality of the brandy used in fortifying should first be established. The presence of too high an amount of "heads" (aldehydes) or "tails" (higher alcohols) can be detected by smelling. The amount of grape aroma present, particularly in muscatels, can also be determined, as well as that of excessive amounts of overripe grapes, concentrate, or boiled-down musts. Overly enthusiastic use of filter aids, charcoal, oak chips, heat, and other treatments may also be recognized in some California wines by the critical taster.

An effort should be made, where blending tests are to be attempted to match a previous wine, first to identify the particular characteristic aroma and flavor of the standard which it is desired to duplicate. This includes a good memory for the original condition of the standard if the new blend is to be aged. Even if the blend is not to be aged, the merits and defects of the standard should be known in order to make the blend with the least possible amount of trial and error.

Because of the sugar present in most dessert wines and their high alcohol content, the actual tasting of these wines is cloying and dehydrating to the palate. Only a small amount should actually be introduced into the mouth, and the wine should all be expectorated as soon as possible. Frequent washings of the mouth with water will help prolong the tasting period, but, at best, it cannot be continued very long. Great attention is therefore directed to the appearance and aroma of the wine by careful tasters, who wish to prolong the period of effective tasting by reducing the amount of actual gustatory examination.

BOTTLING

Much of California dessert wine is sold in bulk but the best is bottled.

Wines are commonly sold by volume; but the volume of wine changes with temperature, expanding as the temperature increases and contracting as the temperature decreases. Water changes in volume by $\pm$ 0.021 per cent of its volume at room temperature (68° F) for each 18° F change in temperature, alcohol changes by $\pm$ 1.05 per cent. The

expansion of a given weight of alcohol is 3½ times that of same weight of water. The coefficient of expansion of sugar solutions is lower than that of water; and that of dessert wine is intermediate, depending largely on alcohol and sugar content. It is sufficient, however, to cause some unfounded complaints of shortage when wine is received at temperatures lower than those at which it was measured and may cause breakage of containers that are filled too full. On freezing, wine, like water, expands in volume, and bottled wines should be protected against extreme fluctuations in temperature in transit or storage. Because of the large cubical coefficient of expansion of wine, care should be taken in barreling to fill the wine barrels at a standard temperature, usually 60° F, or if the temperature is over 60° to fill to above 50 gallons so that the wine will not contract to below 50 gallons on cooling. Wine barrels are usually made to 54 gallons' capacity. Shippers should state plainly to buyers that a standard barrel is 50 gallons but that additional space is provided for expansion; that headspace in a barrel does not indicate that the buyer is not getting 50 gallons of wine. In shipping large containers of wine, headspace to allow for expansion must be provided. The container may be protected against breakage by providing it with a vent hole or low-pressure safety valve.

Preparation for Bottling.—The wine maker must be sure that the wine is properly blended and clarified before bottling. But the character of the wine should not be harmed by excessive treatment. The fruity varietal flavor and light color of muscatel are its chief attractions, and these should not be lost by undue aging or treatments prior to bottling. Most California dessert wines are filtered through a pad filter just prior to bottling. These filters should be regularly cleaned and their performance checked frequently during bottling. *If necessary,* amounts of sulfur dioxide up to 50 or 75 parts per million may be added to control undesirable microörganisms. (See p. 146.)

Bottles.—There is far too wide a variation in the size and shape of bottles used for California dessert wines. In the pre-Prohibition era, quart bottles, usually brown or green in color, were used for California wines. A somewhat smaller bottle is now ordinarily used. The industry should standardize on some one size. Many odd and some fantastic-shaped bottles are now found on the market. Although some of these may prove amusing to a certain clientele, they are not designed to conform to custom or to provide a bottle which may be laid on the side for aging. Well-proportioned and desirable bottles for dessert wines are shown in figure 13.

The general use of mechanical fillers makes it necessary that the bottles should be of a good strength in order to stand the movement

through the bottling machine without breaking. A few bottles from each lot purchased should be examined by means of polarized light to determine the relative freedom of the bottles from defects. If too many bottles are of uneven thickness, nonuniform color, or contain air bubbles, the lot should be rejected. Also, if breakage in the bottling line is high, the bottle manufacturer should be warned.

Some difficulty with certain types of bottles has been experienced because of the presence of a high aluminum content in the glass. If this type of cloudiness or precipitation is suspected, the sediment should be examined chemically.

Fig. 13.—Bottles used for dessert wines, illustrating shape and type of closure.

The bottles for sweet wines should be washed before using. Used bottles are not recommended. The bottles may be washed with some detergent—soda ash, trisodium phosphate, and metaphosphate solutions are commonly used—rinsed with clean, sterile water, and allowed to dry before filling. The cleaned bottles should not be allowed to remain in the winery unfilled, lest they collect dust or become contaminated.

Bottling.—Formerly filling was done largely by hand directly from the cask. In small wineries this method is still used. For the moderate-sized winery, fillers which are semiautomatic and handle six or more bottles at a time may be used. The larger wineries should use the completely automatic fillers. This latter type of filler is expensive; but it requires little attention, fills each bottle with the same amount of liquid, and can be obtained in a variety of styles and sizes. The spouts should reach nearly to the bottom of the bottle in order to prevent excess foaming and oxidation.

The bottling room should be light, easily cleaned, free of sources of contamination, and well ventilated. The fillers must be kept clean dur-

ing use, and before and after operating they should be washed and sterilized. A little of the wine to be bottled may also be rinsed through the machine before starting. This wine must be discarded. All equipment with which the wine comes in contact, from the polishing filter to the bottle, should be of corrosion-resistant material. Considerable economy in operating the bottling room can be effected in the large plant by mechanizing all movements of the bottles and arranging the equipment properly. (See fig. 10, p. 70.)

Dessert wines susceptible to spoilage by lactic-acid bacteria should be either filled hot into the bottle or pasteurized after bottling. The bottles should be filled, whether by hand or by mechanical filler, well into the neck of the bottle. The space remaining in the neck should be uniform, and according to Pedersen and co-workers[153] it is best even with fortified sweet wines such as port, to fill the bottle almost full in order to prevent undesirable changes in storage.

Closures.—Screw caps alone or in conjunction with short corks are more widely used for dessert wines in California than straight corks. The cap should seat properly and seal the bottle completely. Certain types of metal closures are made so that a seal must be broken before opening. These assure the buyer that the wine has not been tampered with before purchasing. Other types of closure are made in one piece with the metal capsule. These also have a tamperproof seal in certain cases. Although the tamperproof features are good, the important points, for any type of closure, are that the closure hold the wine and not leak nor communicate any foreign taste to the wine. If the dessert wine is to be aged in the bottle, straight corks are desirable. These corks should be of good size so that leakage does not occur. Sometimes corks with a wooden top are used so that the cork may be removed and returned to the bottle. These are appropriate for dessert wines, since the wine will not spoil easily in a half-full bottle.

Capsuling and Labeling.—The final operations before shipment are placing a metal foil or cellulose cap over the closure and adding the proper labels. While all of these operations were once done by hand, machinery is now available for most of them. Automatic labeling apparatus is particularly useful. The names used for California dessert wines are outlined on pages 21–33. The information required by law on the label varies from state to state and is frequently changed. The Wine Institute or the Alcohol Tax Unit of the United States Bureau of Internal Revenue should therefore be consulted before any labels are printed. General information such as: type of wine, contents of bottle,

[153] Pedersen, C. S., H. E. Goresline, A. L. Carl, and E. A. Beavens. Keeping quality of bottled wines. Industrial and Engineering Chemistry, industrial edition 33:304–7. 1941.

alcohol content, and bottler's name, are required. Some statements are prohibited (for example, misleading statements of quality). The size of type which may be used is specified for certain information printed on the label. The design on the label should be simple and dignified.

BACTERIAL DISEASES AND OTHER DISORDERS OF DESSERT WINES[154]

The higher alcoholic content of fortified dessert wines renders them less susceptible to many of the bacterial diseases, and their higher pH value to the disorders, to which the table wines are subject (Bulletin 639, p. 120–27.) Still the dessert wines are subject to bacterial diseases during fermentation and prior to fortification and may even undergo spoilage by alcohol-tolerant microörganisms after fortification. Oxidation and reduction of the wines during aging may bring about darkening and discoloration, or formation of turbidities and deposits similar to those formed in wines of lower alcohol content. The higher sugar content, the higher alcohol content, and the lower acidity modify the nature and extent of this nonbacterial spoilage.

MICROBIOLOGICAL SPOILAGE

During Fermentation.—The most serious spoilage observed during fermentation is the rapid acetification of musts fermented at high temperatures without the use of sulfur dioxide or pure yeast. Cruess and Quaccia[155] observed the production of as much as 0.4 grams of acetic acid per 100 cc of muscat must in 48 hours under such conditions. Later observations by Cruess[156] on similar abnormal fermentations which occurred during the 1936 season, another hot season like that in 1934, showed that such rapid acetification could be prevented by use of sulfur dioxide, pure yeast starters, and proper cooling during fermentation. While muscat must was most susceptible to this type of spoilage, it was observed also in Flame Tokay and Carignane musts. Cruess and Quaccia in 1934 believed that the causative agent was a yeast capable of forming abnormally high amounts of volatile acid, but later (1937) Cruess reported that microscopic examination showed the presence of long rod-shaped bacteria believed to be lactic-acid bacteria. Vaughn,[157] however, found the causative organisms to be several unusual strains

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[154] General references on this subject in addition to specific footnotes given in the section are listed on p. 176–77.

[155] Cruess, W. V., and L. Quaccia. Observations in spoiling of must by yeasts. Fruit Products Journal 4:109. 1934.

[156] Cruess, W. V. Observations of '36 season on volatile acid formation in muscat fermentations. Fruit Products Journal 16:198–200, 215, 219. 1937.

[157] Vaughn, Reese H. Some effects of association and competition on *Acetobacter*. Journal of Bacteriology 36:357–67. 1938.

of *Acetobacter*. Grapes heavily infested with these acetic acid bacteria, when crushed and fermented at high temperature, undergo an incipient alcoholic fermentation at first because these bacteria do not attack sugar as rapidly as yeast does. As soon as small quantities of alcohol are produced, however, the alcohol is rapidly converted into acetic acid by these bacteria. The accumulation of acetic acid and the prevailing high temperature retard or prevent the activities of yeast, and the must sticks. Lactic acid bacteria may be involved in this spoilage also since in association with acetic acid bacteria they too produce volatile acids as well as fixed acid. Such a must is "mousy" in flavor and should be discarded because it cannot be refermented and made into a satisfactory wine even for distilling material. To control this spoilage Cruess recommends the addition of not less than 100 parts per million of sulfur dioxide (3½ ounces liquid sulfur dioxide or 7 ounces of potassium metabisulfite per ton of grapes crushed). Cooling during fermentation is necessary also. (See p. 42.) The acetic acid bacteria are extremely sensitive to sulfur dioxide.

After Fortification.—Fortified dessert wines, because of their high alcohol content, are relatively resistant to attack by the common rod-shaped lactic acid bacteria which are so often found in table wines. Spoilage of dessert wine by alcohol-tolerant lactic acid bacteria has been reported to occur by several investigators in recent years. Fevrier[158] reported a bacterial disease in South African wines containing 18 per cent alcohol, and Niehaus[159] reported "mannitic" bacteria in wines from the same locality. Otani[160] described four new species of lactobacilli capable of growing in sake containing from 22 to 26 per cent alcohol. Fornachon[161] isolated rod-shaped lactic acid bacteria from fortified Australian wines. Although several instances of the occurrence of similar lactic acid bacteria in California fortified wine have been observed,[162] they have not been investigated in detail.

The most common and serious disease of fortified California wines is caused by an organism which, because of its resemblance under the micsroscope to a tangled mass of wet hair (fig. 14) has been called the "hair bacillus"; it has been termed also "cottony mold," and "Fresno mold." Its occurrence in fortified wines was reported upon by Douglas

[158] Fevrier, F. A bacterial disease in wine. Union of South Africa Department of Agriculture Journal 12:120–22. 1926.

[159] Niehaus, C. J. G. Mannitic bacteria in South African sweet wines. Farming in South Africa 6:443–44. 1932.

[160] Otani, Y. Untersuchungen ueber der Hyochi-bazillen im Sake. Hokkaido Imperial University Faculty of Agriculture Journal 34(pt. 2):51–142. 1936.

[161] Fornachon, J. C. M. A bacterium causing disease in fortified wine. Australian Journal of Experimental Biology and Medical Science 14:215–22. 1936.

[162] Douglas, H. C., and R. H. Vaughn. Unpublished observations.

and Cruess in 1936,[163] and a more detailed report made by Douglas and McClung. They describe the spoilage as follows:

Spoilage is characterized by an extensive, flocculent, amorphous sediment in the bottom of the container with the supernatant liquid remaining perfectly clear. At no time does the wine, unless shaken severely, become turbid as it does with other bacterial diseases. Chemical examination of such wines reveals ordinarily that there has been but little change in composition. Upon prolonged storage at room tempera-

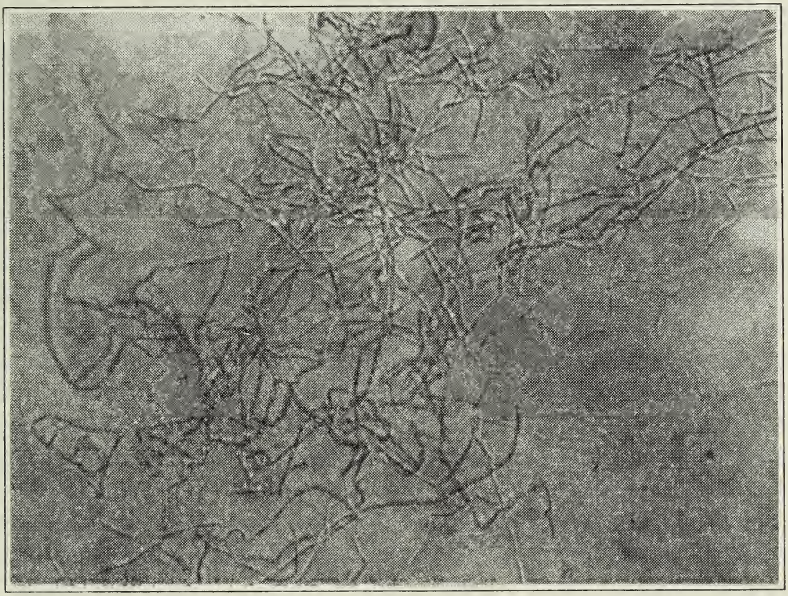

Fig. 14.—Typical unstained microscopic appearance of the organism causing flocculent, amorphous sediment in dessert wines. Magnification approximately 1,000. (Preparation by courtesy of H. C. Douglas.)

ture, there is an increase in the volatile and fixed acids of the wine, together with a decrease in reducing sugars and the pH. An occasional sample is found in which some gas has been produced. Microscopic examination of the sediment from such wines reveals masses of long, intertwined filaments. Most frequently affected in the samples examined were Muscatel, Angelica, and sherry types of wine, with occasional samples of port, Tokay, and Malaga. We have encountered no report of spoilage of this kind in dry wines.

The most frequent complaints in this type of disease are from instances in which spoilage occurs after final bottling. Although not affecting the taste greatly, diseased wine is unsightly and the consumer's reaction is naturally unfavorable. Such a reaction may be expected to affect future sales of similar or other types of wines from the same wineries. Since prolonged incubation is often necessary before spoilage takes place, the possibility exists that wine which is apparently sound upon leaving the winery may later develop the growth. The case histories of some of the complaints indicate that this condition prevails in many instances.

[163] Douglas, Howard C., and W. V. Cruess. A note on the spoilage of sweet wine. Fruit Products Journal **15**:310. 1936.

Although the majority of reports of this type of spoilage have been upon bottled wines, positive cultures have been obtained from storage vats, shipping barrels, and tank cars, indicating that wine is often contaminated in the winery before bottling. The possibility exists, however, that at times sound wine may become diseased through the use of contaminated bottling equipment or other equipment with which the wine may come in contact.[164]

The causal organism, the filamentous lactic acid bacteria, develops very slowly even under favorable environmental conditions. Its alcohol tolerance is high for it will grow in diluted sweet wines containing up to 22 per cent of alcohol, but it is very sensitive to sulfur dioxide, even 60 parts per million being sufficient to check development of the organism. The sugar content is not the limiting factor, for the organism will grow in wines containing from 0.2 to 15.0 per cent sugar. The lower the total acid content of the wine the greater its susceptibility to this organism: a total acidity of 0.5 per cent is sufficient to prevent its growth in sweet wine. The optimum pH for growth lies between 4.1 and 4.3 with growth occurring from pH 3.7 to between 5.0 and 6.0. The optimum pH for growth and for metabolism of carbon compounds for several strains of heterofermentative (non-gas-producing) lactic acid bacteria was found by Fornachon, Douglas, and Vaughn[165] to be pH 5 to 6. The optimum growth temperature was 68° to 77° F; at higher temperatures the incubation period is prolonged and in some cases growth is inhibited altogether.

Recent investigations[166] indicate that the organism produces large quantities of mannite from levulose. The mannite present in infected wines crystallizes out in characteristic rosettes of needlelike pointed crystals when a portion of the wine is allowed to dry. Lactic and acetic acids are produced also but in small amounts; gas production was not observed by Douglas and McClung in artificially inoculated media in contrast to conditions in several original wine samples.

To control the spoilage by this organism, sulfur dioxide, pasteurization, or acidification may be used. The infected wine should be filtered, pasteurized by ordinary winery pasteurization procedures, and sulfited to a concentration of 60 to 100 parts per million of sulfur dioxide in the finished wine.

Yeast turbidities have been observed recently in bottled fortified wines. Whether these turbidities are actually due to development of alcohol-tolerant yeast in the wine, to growth of yeast on corks, or to

[164] Douglas, H. C., and L. S. McClung. Characteristics of an organism causing spoilage in fortified sweet wines. Food Research 2:471–75. 1937.

[165] Fornachon, John C. M., Howard C. Douglas, and Reese H. Vaughn. The pH requirements of some heterofermentative species of *Lactobacillus*. Journal of Bacteriology 40:649–55. 1940.

[166] Vaughn, Reese H., *et al.* Unpublished observations.

other causes, is not known. Phaff[167] has isolated from such wines viable species of *Zygosaccharomyces*. In beer, yeast turbidities occur only in well-aerated beer, that is, at a rather high oxidation-reduction potential, rH above 13;[168] otherwise the propagation stops and the yeast cells present precipitate.[169] That a similar relation occurs in wines is known from the fact that addition of sulfur dioxide inhibits yeast turbidities of this type.

In using sulfur dioxide to control the microbial spoilage of fortified sweet wines, it is necessary to realize that the rate of loss of the actively antiseptic, free sulfur dioxide is higher in such wines than in dry table wines because of the more rapid combination of sulfur dioxide with sugar, aldehydes, and other substances. The total sulfur dioxide content is thus not a reliable criterion of the potential preservative power.

NONBACTERIAL DISORDERS

Hazing, clouding, discoloration, and browning of wine and formation of crystalline or amorphous deposits may occur in young or improperly stabilized wines or those which contain excessive quantities of metallic impurities.

The crystalline deposits most commonly observed are those of cream of tartar, calcium tartrate, or mannite. The presence of potassium acid tartrate crystals (cream of tartar) indicates either too short an aging period or insufficient refrigeration, the temperature being too high or the time refrigerated too short. Calcium tartrate crystals occur when the wine dissolves excessive quantities of calcium from improperly washed filter pads, from concrete tanks, or from other sources. Occasionally wine filtered with a diatomaceous filter aid may contain small diatom particles which will settle out. The presence of mannite crystals indicates that the wine has been subjected to attack by one or more types of lactic acid bacteria.

Amorphous Deposits.—Several types of amorphous deposits are encountered in dessert wines: precipitates of oxidized or decomposed tannins and anthocyanin pigments; precipitates of insoluble caramel; precipitates of excess tannin; precipitates of colloidal iron and copper

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[167] Phaff, H. J. Unpublished observations.

[168] rH is the negative logarithm of the calculated hydrogen pressure at which the hydrogen electrode would indicate the same oxidation-reduction potential at the same pH as that of the system under investigation. The higher the values of the rH, the greater is the oxidizing intensity of the system. The rH convention assumes that the electrode potential varies with the pH as does the hydrogen electrode, an assumption which is not strictly correct.

[169] Siebel, F. P., and E. Singruen. Application of oxidation-reduction potential to brewing control. Industrial and Engineering Chemistry, industrial edition 27:1042–45. 1935.

Clerck, Jean de. rH and its applications in brewing. Institute of Brewing Journal 31(n.s.):407–19. 1934.

salts; and precipitates of coagulated gums, proteins, or other colloid, and other organic constituents that may be thrown out of solution.

Gallotannin, obtained principally from gall nuts, is present also in *Vitis vinifera* grapes, according to Girard and Lindet.[170] This on mild hydrolysis yields glucose and the tannic acid of commerce. Phlobatannins are present also.[171] The gallotannins and the phlobatannins on oxidation yield highly polymerized insoluble brown-colored complex compounds usually referred to as melanogallic acid (in case of gallic acid) or simply as melanins. The phlobatannins, the most widely distributed natural tannins, in acid solution are slowly converted into red or brown amorphous, insoluble materials that have been named "phlobaphenes." (See also p. 126.) It is possible that "phlobaphenes" occasionally deposit in wines, particularly when they are heated. Laborde[172] suggested two courses for the oxidation of tannin: either direct oxidation of the tannin material by oxygen followed by oxidation of alcohol to aldehdye; or oxidation of alcohols to aldehdyes first followed by precipitation of an aldehyde complex of tannin. Ribéreau-Gayon[173] found that tannin is an antioxidant in wine and reduces the rate of oxidation of oxidizable constituents like sulfur dioxide and anthocyanins. The stabilization of red wine against precipitation of coloring matter on oxidation has been known since 1905. It is well recognized in the wine industry that the addition of 1 pound of tannin (as grape tannin) per 1,000 gallons stabilizes wine (both white and red) against sedimentation of coloring matter and other oxidizable organic constituents.

The precipitation of red coloring matter was at first believed to occur simply as the result of the direct oxidation of anthocyanin pigments. Trillat (cited in footnote 99, p. 90), Laborde, and Joslyn and Comar[174] have presented evidence to show that it is caused primarily by combination with aldehyde either added or formed by oxidation of alcohol. Ribéreau-Gayon indicates that anthocyanins undergo progressive demethoxylation to yield a derivative capable of polymerization and undergo coagulation if necessary even in the absence of oxygen.

[170] Girard, A., and Lindet. Sur le phlobaphène du raisin. Société Chimique de France Bul. **19** (3 série):583–84. 1898.

[171] For discussion of the natural tannins see:

Nierenstein, M. The natural organic tannins. 319 p. J. & A. Churchill Ltd. London, England. 1934.

Russell, Alfred. The natural tannins. Chemical Reviews **17**:155–86. 1935.

[172] Laborde, J. Recherches sur le viellissement du vin. Revue de Viticulture **48**: 225–30, 241–44; **49**:38–41, 49–51, 65–69. 1918.

[173] Ribéreau-Gayon, Jean. Contribution à l'étude des oxydations et réductions dans les vins. 2d ed. 213 p. (See especially p. 52–55, 92–97.) Delmas-Éditeur, Bordeaux, France. 1933.

[174] Joslyn, M. A., and C. L. Comar. The role of aldehydes in red wine. Industrial and Engineering Chemistry, industrial edition **33**:919–28. 1941.

Iron Casse.—The formation of colloidal ferric phosphate, which subsequently settles out to form a white deposit, has been observed in white dessert wines such as Angelica and muscatel, and particularly in white port. Marsh[175] believes that this occurs, even in dessert wines, only in the range of pH 2.9 to 3.6. California dessert wines usually range from pH 3.7 to 4.1, the bulk being in the range 3.9 to 4.0. Iron casse, however, occurs in dessert wines, particularly when excessive amounts of both iron and copper salts are present. It is encountered frequently in white port. The more heavily decolorized is the white port, the more susceptible is the wine to the formation of a white acid-soluble sediment. This is due to a pickup of phosphate from the charcoal, particularly from bone charcoal. The ferric phosphate casse can usually be controlled by the addition of 1 pound of citric acid per 1,000 gallons of wine. In wines containing large amounts of both iron and copper, ferric phosphate casse may form even in wines above the pH range in which it normally occurs and may not be controlled by addition of citric acid.

Copper Casse.—Copper casse has been found to occur in several white dessert wines containing excessive quantities of copper. Copper casse is seldom a serious problem with sherries even when they are baked with copper coils although copper coils may be undesirable for other reasons. (See p. 106.) Apparently the copper dissolved by the sherry material is largely deposited during the usual cellar treatment. Occasionally, however, sherries with excessive copper content occur. Successful control measures other than precipitation as copper ferrocyanide, which is illegal, have not been developed as yet.

Clouding as a result of the formation of colloidal suspensions of insoluble ferric compounds on oxidation or of insoluble copper compounds on reduction is more likely to occur in dessert wines prepared from must fermented off the skins than from must fermented with the skins and seeds. This may be due either to absorption of tannins or to loss of protective colloids in the latter case. The addition of tannin to wine often but not always stabilizes it against metal casse.

Sulfur dioxide in quantities up to 75 parts per million is also beneficial owing in part to its antioxidative effect and in part to formation of aldehyde sulfonates. By binding the free aldehyde, sulfur dioxide retards precipitation of tannins, anthocyanins, and other organic constituents which form insoluble complexes with free aldehyde. The binding of free sulfur dioxide by aldehydes and sugars reduces its antioxidative and antiseptic power. If white wines contain excessive amounts of copper, then sulfur dioxide, even in small amounts, exaggerates copper casse.

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[175] Marsh, G. L. Metals in wine. The Wine Review **8**(9):12–13, 24; (10):24–26, 28–29. 1940.

Oxidasic Casse.—Oxidasic casse, the rapid yellowing of white wines and browning of red in the presence of grape oxidase, may occur in dessert as well as table wines. Hussein and Cruess[176] found that grape peroxidase in the presence of 20 per cent alcohol retains over 60 per cent of the activity it has in the absence of all alcohol. Pasteurization, acidification, or addition of sulfur dioxide inhibits grape peroxidase.[177]

ANALYSES[178]

The chemical analysis of a wine is of great assistance to the wine maker in blending procedures and in deciding upon their rational handling and treatment. It is not at the present time, however, a satisfactory method of deciding upon the quality of a wine although certain types of spoilage may be recognized by their effect on the composition of the wine.

The chemical analysis of dessert wines is usually made by chemists who have had considerable experience in wine analysis. The following procedures, which are chiefly adapted for control work, have been selected with this fact in mind. For more detailed discussion of the several methods, consult the references on pages 178 to 179. Some of the procedures outlined require training in analytical chemistry and should not be attempted by those who have not had such training. Other procedures are comparatively simple.

ALCOHOL

By Ebullioscope.—The method is based on the regular variation in the boiling point of mixtures of alcohol and water with alcohol content. For wines having an extract content (see p. 157) up to 5, accurately dilute the wine 1:1 with water, using pipettes to measure the wine and the water. With wines having extract contents from 5 to 10, dilute 2:1 with water and dilute 3:1 for wines having extract contents of over 10.

In the presence of sugar, the ebullioscope gives high results since sugar and other nonalcohol soluble solids decrease the boiling point of alcohol-water solutions.[179] The effect of sugar may be reduced by diluting the wine as outlined above, but this introduces other errors. For approximate results the alcoholic content may be determined by suitable dilution. As used by United States gaugers, the wine is diluted to an extract

[176] Hussein, A. A., and W. V. Cruess. Properties of the oxidizing enzymes of certain vinifera grapes. Food Research 5:637–48. 1940.

[177] Hussein, A. A., and W. V. Cruess. A note on the enzymic darkening of wine. Fruit Products Journal 19:271. 1940.

[178] General references on this subject in addition to those given in specific footnotes in the section are listed on p. 178–79.

[179] Love, R. F. A table for ebulliometers. Industrial and Engineering Chemistry, analytical edition 11:548–50. 1939.

content of not over 6 per cent and alcohol content of not over 11 per cent. More accurate determinations with the ebullioscope can be made by use of correction tables such as those of Love or of Churchward.[180] Another procedure is to distill the wine and determine the alcoholic content of distillate by ebullioscope.

As the boiling point of water varies with the atmospheric pressure, it must be ascertained at the time each series of determinations is made. A sliding scale, on which the boiling point should be adjusted from day to day or even twice a day, accompanies the instrument and is used for calculating the alcohol content.

Pipette 15 cc of water into the boiling chamber of the ebullioscope, leave the condenser empty, insert the thermometer, and heat evenly with a carefully adjusted alcohol burner or gas microburner. The temperature reading is taken when the mercury column is constant for about 30 seconds. The temperature reading for this blank determination is set on the sliding scale opposite 0.0 per cent alcohol. The boiling water and condenser water are then drained, the boiling chamber rinsed with a little of the wine to be tested (diluted, if necessary), 50 cc of wine placed in the chamber, the condenser filled with cold water, the thermometer replaced, heat applied, and the boiling point determined. The reading is noted on one side of the sliding scale; opposite this temperature the alcohol percentage in the wine (or in the diluted wine) is read. (Churchward prefers to use a specially constructed table for the Dujardin-Salleron ebullioscope, as is customary for other ebulliometers.) If the wine has been diluted, this is multiplied by the proper factor. This method is usually accurate enough for the alcohol determination on the fermenting wine to be fortified or for routine winery operations. Replicate results by the method should check to within $\pm$ 0.25 per cent.[181] For more exact results, the following method is recommended.

By Distillation.—For analysis by distillation, pipette 100 cc of the wine into an 800-cc Kjeldahl flask and add 50 cc of distilled water. Connect to a condenser and distill about 97 cc into a 100-cc volumetric flask. Bring the flask to 68° F (20° C) and make the volume up to the mark with distilled water. Shake and bring to 68° again. Empty the alcohol into a cylinder and float an alcohol hydrometer in it. Be sure that the hydrom-

[180] Churchward, C. R., and B. G. Johns. The use of the Dujardin-Salleron ebulliometer for the determination of the alcoholic strength of wines. Australian Chemical Institute Journal and Proceedings 7:18–30. 1940.

Churchward, C. R. The Dujardin-Salleron ebulliometer. Australian Chemical Institute Journal and Proceedings 7:71–72. 1940.

[181] Joslyn, M. A., G. L. Marsh, and J. Fessler. A comparison of several physical methods for the determination of the alcohol content of wine. Association of Official Agricultural Chemists Journal 20:116–30. 1937.

Valaer, P. Report on alcohol by the use of the ebullioscope. Association of Official Agricultural Chemists Journal 21:175–77. 1938.

eter is clean and dry and do not touch it except at the top. Carefully make a reading and then take the temperature of the solution. Correct the reading by reference to table 32. (If the hydrometers are calibrated at some other temperature, a different table will be necessary.) Results by this method should check to within ± 0.15 per cent.

Chemical Analysis by Acid Dichromate.—Of the several available chemical methods for the determination of ethyl alcohol, the most reliable depends on the determination of the quantity of acid dichromate required to oxidize alcohol to acetic acid,[182] or the amount of alkaline permanganate necessary for the complete oxidation of alcohol.[183] The oxidizing mixture is added in measured excess and the quantity remaining in solution is determined by back titration with a suitable reducing agent. More recently the excess of oxidizing agent has been determined colorimetrically.[184]

For the Semichon-Flanzy procedure, pipette 20 cc of wine of 14 per cent alcohol content or below, or 10 cc of dessert wine into a small 100-cc round-bottom flask and add about 30 cc of distilled water. Distill directly through a small condenser into a 100-cc volumetric flask until a little over half the liquid is distilled over. Make up to volume at 15° C with distilled water.

Place 20 cc of potassium bichromate solution (33.832 grams dissolved in water and brought to 1 liter at 15° C) and 10 cc of concentrated H_2SO_4 (sulfuric acid) in a 250-cc Erlenmeyer flask (preferably a glass-stoppered flask). Mix and then cool in running water to room temperature.

Add 5 cc of the alcohol distillate to the mixture, mix and stopper the flask with a clean rubber or glass stopper. Let stand at room temperature, with occasional mixing, for 10 minutes.

Titrate the excess chromate with the ferrous ammonium sulfate solution (135.310 grams in 700 cc of cold water to which are added 20 cc of concentrated H_2SO_4 and the solution made to 1 liter; 2 cc of this solution should correspond exactly to 1 cc of the potassium bichromate solution) using a porcelain spot plate with 1 per cent potassium ferricyanide as external indicator. The liquid, which is brown at first, soon turns green. As soon as it turns green, add the ferrous ammonium sulfate dropwise and place a drop of the titration mixture on a drop of the

[182] Semichon, M. L., and M. Flanzy. Dosage de l'alcool dans les vins et spiritueux par l'emploi du melange sulfi-chromique. Annales des Falsifications et des Fraudes 22:139–52. 1929.

[183] Friedmann, Theodore E., and Rosalind Klaas. The determination of ethyl alcohol. Journal of Biological Chemistry 115:47–61. 1936.

[184] Gibson, John G., 2d, and Harry Blotner. The determination of ethyl alcohol in blood and urine with the photoelectric colorimeter. Journal of Biological Chemistry 126:551–59. 1938.

TABLE 32

Corrections of Alcohol Hydrometers Calibrated at 60° F, in Per Cent by Volume of Alcohol, When Used at Temperatures Above or Below 60° F

Observed alcohol content	To or from the observed per cent alcohol																	
	Add			Subtract														
	At 57° F	At 58° F	At 59° F	At 61° F	At 62° F	At 63° F	At 64° F	At 65° F	At 66° F	At 67° F	At 68° F	At 69° F	At 70° F	At 72° F	At 74° F	At 76° F	At 78° F	At 80° F
per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	*0.14*	*0.10*	*0.05*	0.05	0.10	0.16	0.22	0.28	0.34	0.41	0.48	0.55	0.62	0.77	0.93	....	....	....
2	*.14*	*.10*	*.05*	.05	.11	.17	.23	.29	0.35	0.42	0.48	0.56	0.63	0.78	0.94	1.10	1.28	1.46
3	*.14*	*.10*	*.05*	.06	.12	.18	.24	.30	0.36	0.43	0.50	0.57	0.64	0.80	0.96	1.13	1.31	1.50
4	*.14*	*.10*	*.05*	.06	.12	.19	.25	.32	0.38	0.45	0.52	0.59	0.67	0.83	1.00	1.17	1.35	1.54
5	*.15*	*.10*	*.05*	.07	.13	.20	.26	.33	0.40	0.47	0.54	0.62	0.70	0.86	1.03	1.21	1.40	1.60
6	*.17*	*.11*	*.06*	.07	.14	.20	.27	.34	0.42	0.50	0.57	0.66	0.74	0.90	1.09	1.27	1.46	1.66
7	*.18*	*.12*	*.06*	.07	.14	.21	.29	.36	0.44	0.52	0.60	0.68	0.77	0.94	1.13	1.32	1.52	1.73
8	*.19*	*.13*	*.06*	.08	.16	.23	.31	.39	0.47	0.55	0.64	0.73	0.81	0.99	1.18	1.38	1.59	1.80
9	*.21*	*.14*	*.07*	.08	.16	.24	.32	.41	0.50	0.58	0.67	0.76	0.86	1.04	1.25	1.46	1.67	1.89
10	*.23*	*.16*	*.08*	.08	.17	.25	.34	.43	0.52	0.61	0.71	0.80	0.90	1.10	1.32	1.54	1.76	1.99
11	*.25*	*.16*	*.08*	.09	.18	.27	.37	.46	0.56	0.65	0.75	0.85	0.96	1.16	1.39	1.61	1.84	2.09
12	*.27*	*.18*	*.09*	.10	.20	.29	.39	.49	0.59	0.70	0.80	0.91	1.02	1.23	1.46	1.70	1.94	2.20
13	*.29*	*.19*	*.10*	.10	.21	.31	.42	.52	0.63	0.74	0.85	0.97	1.08	1.31	1.55	1.80	2.05	2.31
14	*.32*	*.21*	*.11*	.11	.22	.32	.44	.55	0.66	0.78	0.91	1.02	1.14	1.39	1.65	1.91	2.17	2.44
15	*.35*	*.23*	*.12*	.12	.24	.35	.48	.60	0.71	0.84	0.97	1.10	1.23	1.50	1.76	2.03	2.30	2.58
16	*.37*	*.24*	*.12*	.13	.26	.38	.52	.65	0.77	0.90	1.03	1.17	1.31	1.60	1.88	2.16	2.44	2.72
17	*.40*	*.26*	*.13*	.14	.27	.41	.54	.68	0.82	0.96	1.10	1.25	1.40	1.70	1 99	2.28	2.58	2.87
18	*.44*	*.29*	*.14*	.14	.29	.44	.58	.73	0.88	1.03	1.18	1.33	1.49	1.80	2.10	2.41	2.72	3.02
19	*.47*	*.32*	*.16*	.15	.30	.46	.62	.78	0.94	1.10	1.26	1.42	1.58	1.90	2.22	2.54	2.86	3.17
20	*.51*	*.34*	*17*	.16	.32	.49	.66	.82	0.98	1.15	1.33	1.48	1.65	2.00	2.32	2.65	2.98	3.33
21	*.53*	*.35*	*.18*	.17	.34	.51	.68	.85	1.02	1.20	1.38	1.54	1.72	2.06	2.41	2.76	3.10	3.45
22	*.56*	*.38*	*.19*	.17	.36	.53	.71	.90	1.07	1.25	1.44	1.61	1.78	2.13	2.48	2.84	3.20	3.56
23	*.58*	*.40*	*.20*	.18	.37	.55	.74	.92	1.11	1.30	1.49	1.66	1.84	2.20	2.56	2.93	3.30	3.67
24	*0.60*	*0.40*	*0.20*	0.18	0.38	0.56	0.77	0.96	1.16	1.35	1.54	1.72	1.91	2.27	2.65	3.03	3.40	3.78

Source of data:
United States Bureau of Internal Revenue. Regulations No. 7 relative to the production, fortification, and tax payment, etc., of wine. 188 p. United States Government Printing Office, Washington, D. C. 1937.

ferrocyanide; as long as there is an excess of chromate, this latter solution will turn a yellowish orange in color; as soon as the ferrous salt is in excess, the indicator turns to a characteristic blue. The solution in the flask will become blue-green if it has an excess of ferrous solution.

The alcohol content in the wine is calculated as follows:

If n is the number of cubic centimeters of the ferrous ammonium

TABLE 33

SPECIFIC GRAVITY OF ALCOHOL SOLUTIONS AT 60° F
(Assuming specific gravity of water at 60° F as unity)

Alcohol	Specific gravity	Alcohol	Specific gravity
per cent		*per cent*	
0.0	1.00000	11.5	0.98487
0.5	0.99925	12.0	.98430
1.0	.99850	12.5	.98374
1.5	.99776	13.0	.98319
2.0	.99703	13.5	.98264
2.5	.99630	14.0	.98210
3.0	.99559	14.5	.98157
3.5	.99488	15.0	.98104
4.0	.99419	15.5	.98051
4.5	.99350	16.0	.97998
5.0	.99282	16.5	.97946
5.5	.99215	17.0	.97895
6.0	.99150	17.5	.97844
6.5	.99085	18.0	.97794
7.0	.99022	18.5	.97744
7.5	.98960	19.0	.97694
8.0	.98899	19.5	.97645
8.5	.98838	20.0	.97596
9.0	.98779	20.5	.97546
9.5	.98720	21.0	.97496
10.0	.98661	21.5	.97446
10.5	.98602	22.0	.97395
11.0	0.98544	22.5	0.97344

Source of data:
United States Bureau of Internal Revenue. Regulations No. 7 relative to the production, fortification, tax payment, etc., of wine. 188 p. United States Government Printing Office, Washington, D. C. 1937.

sulfate solution added to reduce excess chromate, then the alcohol content of the wine itself is $(20 - \frac{n}{2})$ for the 20 cc of dry wine used, or double that for the 10 cc of sweet wine used.

For example if $n = 8.50$, then alcohol content, in per cent by volume $= 20 - \frac{8.50}{2} = 20 - 4.25$, or 15.75.

The method depends on the complete oxidation of alcohol to acetic acid. The acid, alcohol, and chromate concentrations, and time at room temperature must be carefully adhered to in order to achieve complete oxidation of alcohol to acetic acid without oxidizing the latter further.

The concentrations of reagents used have been so adjusted that at 15° C, 1 cc of dichromate solution completely oxidizes 7.943 mg of alcohol to acetic acid and corresponds to 1 per cent by volume of alcohol in the original wine. The presence of reducing matter other than alcohol in distillate obviously interferes with the determination. Usually this is small for French wines, and with the average California wine the recovery of alcohol by this method is accurate to $\pm$ 0.05 per cent alcohol. The dichromate solution is fairly stable but the ferrous ammonium sulfate solution will deteriorate unless protected from oxidation as by charging with ordinary gas or hydrogen.

Modified Dichromate Procedure.—The above procedure may be modified by the use of an internal indicator such as diphenylamine, or diphenylamine sulfonic acid[185] instead of the external indicator. Proceed as above until the titration. To the mixture of excess dichromate and acetic acid or to an accurately measured aliquot, add a measured excess (25 to 50 cc) of ferrous ammonium sulfate solution. (It is better to make up the mixture to 100 cc and pipette out 25 cc, to which is added the acid ferrous ammonium solution.) Then add 4 drops of diphenylamine indicator (1 gram of diphenylamine dissolved in 100 cc of concentrated H_2SO_4) and titrate the excess of ferrous salt with dichromate solution. In the presence of excess ferrous salt, the solution is green; as standard dichromate solution is run in, the green color changes to a blue-green and then to an intense blue or violet color. Titrate the volume of ferrous ammonium sulfate solution added in the above step with the dichromate solution. Add the same number of drops of indicator and 5 cc of concentrated sulfuric acid to the measured volume of ferrous ammonium sulfate solution.

The diphenylamine end point is improved by the addition of 15 cc of phosphoric acid mixture (150 cc of concentrated H_2SO_4 + 150 cc H_3PO_4 sirup diluted to 1 liter) to bind the ferric ion complexes:[186]

Calculate the weight in grams of the alcohol present in the aliquot used for titration from the reaction:

$$2K_2Cr_2O_7 + 3C_2H_5OH + 8H_2SO_4 = 2Cr_2(SO_4)_3 + 3CH_3CO_2H + 2K_2SO_4 + 11\,H_2O.$$

Then the concentration of alcohol present in the distillate is calculated

[185] Sarner, L. A., and I. M. Kolthoff. Diphenylamine sulfonic acid as a new oxidation-reduction indicator. American Chemical Society Journal 53:2902–05. 1931.

Sarner, L. A., and I. M. Kolthoff. Indicator corrections for diphenylamine, diphenylbenzidine, and diphenylamine sulfonic acid. American Chemical Society Journal 53:2906–9. 1931.

[186] Bottger, William (Translated by Ralph E. Oesper). Newer methods of volumetric chemical analysis. 268 p. (See particularly section on oxidation-reduction indicators by Erna Brennecke. p. 155–80.) D. Van Nostrand Company, Inc., New York, N. Y. 1938.

as grams per 100 cc, and converted into percentage of alcohol by volume by reference to table 17 in Bulletin 652.

Another modification of the dichromate procedure has been developed by Fessler.[187]

The specific gravity of alcohol solutions from 0.0 to 22.5 per cent is given in table 33.

TOTAL ACID

For white wines, pipette 10 cc of wine into a 500-cc flask, and if carbon dioxide is present, add 250 cc of boiling distilled water. Add 3 to 5 drops of phenolphthalein indicator solution; and titrate with standardized 0.1 *N* NaOH (0.1 normal sodium hydroxide) to a distinct pink color, or until 1 or 2 drops of NaOH produce no perceptible change. One may best observe the color change by holding the flask just above a well-lighted white surface. The total acidity, expressed as grams of tartaric acid per 100 cc, is obtained by multiplying the number of cubic centimeters of 0.1 *N* NaOH used in titrating by 0.075.

For dark and red wines, measure 2.0 cc of wine into a 500-cc flask. Add, if carbon dioxide is present, 250 cc of boiling distilled water and several drops of phenolphthalein indicator. Disregard the red to bluish-black color change, and titrate with 0.1 *N* NaOH to a pink end point. The total acidity expressed as grams of tartaric acid per 100 cc is obtained by multiplying this titration figure in cubic centimeters by 0.375. For this titration, a microburette is preferred, although a 10-cc burette graduated in 1/20-cc intervals is satisfactory. More dilute NaOH may be used also, for example, 0.033 *N*. In this case a regular burette may be used.

VOLATILE ACID

The method of analysis for volatile acid is based on the fact that certain of the acids formed in large amounts in spoiled wine (mainly acetic) are distilled by steam at atmospheric pressure. With a 10-cc pipette, introduce 10 cc of wine into the central tube of a volatile-acid distillation apparatus. Add 150 cc of recently boiled hot distilled water to the outer flask. Tightly connect the apparatus as directed by the manufacturer. Start cold water running through the condenser, and apply heat to the outer flask. When the water has boiled for a moment, close the pinchcock on the outlet of the outer flask, and distill until 100 cc has been collected in a 300-cc flask. Heat the distillate to boiling, add 3 to 5 drops of phenolphthalein solution, and titrate with 0.1 *N* NaOH. The volatile acid content as grams of acetic acid per 100 cc of wine is obtained by multiplying the titration in cubic centimeters by 0.06. Somewhat more accurate results may be obtained for the titration by using a more dilute NaOH solution.

[187] Fessler, J. H. Alcohol determination by dichromate method. Wines and Vines 22(4):17–18. 1941.

EXTRACT

Pipette 100 cc of wine into a 250-cc beaker, add 50 cc of distilled water, place over a moderate source of heat, and evaporate to approximately 50-cc volume. Remove from the heat and cool to room temperature. Dilute back to the original volume in a 100-cc volumetric flask by adding distilled water and mix thoroughly. Adjust the temperature to exactly 20° C and then place a portion of the liquid in a glass hydrometer cylinder. Read off the approximate extract with a Brix or Balling hydrometer. When the dealcoholized wine has been adjusted to the same volume as that of the original sample, the reading gives the approximate extract direct as grams per 100 cc of wine. The hydrometer reading will have to be corrected for the influence of temperature, if the reading is made at a temperature different from that at which the hydrometer is calibrated. (See table 34.) If specific-gravity hydrometers are used, the readings may be converted to degree Balling by reference to table 35.

TABLE 34

CORRECTIONS FOR BRIX OR BALLING HYDROMETERS CALIBRATED AT 20° C (68° F)

Temperature of solution		Observed percentage of sugar						
		0	5	10	15	20	25	30
Below calibration		Subtract						
° C	*° F*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
15	59.0	0.20	0.22	0.24	0.26	0.28	0.30	0.32
15.56	60.0	.18	.20	.22	.24	.26	.28	.29
16	60.8	.17	.18	.20	.22	.23	.25	.26
17	62.6	.13	.14	.15	.16	.18	.19	.20
18	64.4	.09	.10	.11	.12	.13	.13	.14
19	66.2	0.05	0.05	0.06	0.06	0.06	0.07	0.07
Above calibration		Add						
° C	*° F*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
21	69.8	0.04	0.05	0.06	0.06	0.07	0.07	0.07
22	71.6	.10	.10	.11	.12	.13	.14	.14
23	73.4	.16	.16	.17	.17	.20	.21	.21
24	75.2	.21	.22	.23	.24	.27	.28	.29
25	77.0	.27	.28	.30	.31	.34	.35	.36
26	78.8	.33	.34	.36	.37	.40	.42	.44
27	80.6	.40	.41	.42	.44	.48	.52	.52
28	82.4	.46	.47	.49	.51	.56	.58	.60
29	84.2	.54	.55	.56	.59	.63	.66	.68
30	86.0	.61	0.62	0.63	0.66	0.71	0.73	0.76
35	95.0	0.99	1.01	1.02	1.06	1.13	1.16	1.18

Source of data:
Association of Official Agricultural Chemists. Official and tentative methods of analysis. 5th ed. p. 664. Washington, D. C. 1940.

If the alcohol has been determined by distillation, the solution remaining in the Kjeldahl flask may be used for the extract determination. The solution is poured into a 100-cc volumetric flask. The sides of the Kjeldahl flask are washed down and this solution also poured into the volumetric flask. This is repeated several times until the extract is all removed

TABLE 35

Specific Gravity at 60° F Corresponding to Readings of the Balling Hydrometer

(Assuming specific gravity of water at 60° F as unity)

Balling	Specific gravity	Balling	Specific gravity	Balling	Specific gravity
degrees		*degrees*		*degrees*	
0.00	1.0000	10.0	1.03933	20.0	1.0814
0.50	1.0019	10.5	1.0414	20.5	1.0836
1.00	1.0038	11.0	1.0434	21.0	1.0859
1.50	1.00575	11.5	1.0454	21.5	1.0881
2.00	1.0077	12.0	1.04746	22.0	1.0903
2.50	1.00966	12.5	1.0495	22.5	1.0926
3.00	1.01163	13.0	1.05153	23.0	1.0949
3.50	1.01356	13.5	1.05356	23.5	1.0971
4.00	1.0155	14.0	1.05556	24.0	1.0994
4.50	1.0174	14.5	1.05753	24.5	1.1017
5.00	1.01926	15.0	1.05943	25.0	1.1040
5.50	1.0212	15.5	1.06163	25.5	1.1063
6.00	1.02323	16.0	1.06386	26.0	1.1086
6.50	1.0252	16.5	1.0660	26.5	1.1109
7.00	1.02706	17.0	1.06803	27.0	1.1133
7.50	1.02906	17.5	1.0701	27.5	1.1155
8.00	1.0313	18.0	1.07233	28.0	1.1180
8.50	1.03336	18.5	1.07456	28.5	1.1203
9.00	1.03523	19.0	1.0769	29.0	1.1227
9.50	1.0372	19.5	1.07926	29.5	1.1251
				30.0	1.1274

Source of data:
United States Bureau of Internal Revenue. Regulations No. 7 relative to the production, fortification, and tax payment, etc., of wine. 188 p. United States Government Printing Office, Washington, D. C. 1937.

from the Kjeldahl flask. The volumetric flask is then brought to 20° C, made to volume with distilled water, and shaken, and the extract content determined with the hydrometer as indicated above.

The extract content may also be obtained by pipetting 50 or 100 cc of the wine into a tared platinum or porcelain dish, evaporating off the moisture at 70° C in a vacuum oven, and weighing.

REDUCING SUGARS

The extract content minus 2.5 usually gives the sugar content accurately enough in the sweet dessert wines. Occasionally in sherries it is desirable to know the actual reducing-sugar content.

The volumetric method given below is based on the Lane and Eynon titration method for determining substances capable of reducing copper

in alkaline tartrate solution. Although the copper-reducing substances in wine are largely sugars, other reducing matter is present and must be removed. The standard procedure is to clarify with lead acetate and then remove the excess lead with sodium oxalate. The treatment with charcoal given here is simpler though less accurate. White wines contain much less of interfering substances than red wines.

Dealcoholize the wine (as for extract), cool, and make to the original volume by adding distilled water. With white wine, filter if not brilliantly clear. With red wine, decolorize by shaking 100 cc of wine with about 5 grams of acid-washed decolorizing carbon and then filtering.

Immediately before use, prepare the Soxhlet reagent by mixing 50 cc each of Fehling's A and B solutions[188] in a clean, dry flask.

Pipette accurately 25 cc of the mixed Soxhlet reagent into a clean 300-cc Erlenmeyer flask. To standardize the method, fill the burette with a standardized 0.5 per cent dextrose solution and also pipette 20 cc of this solution into the flask. Set the flask on a wire gauze and place the burette just above the mouth of the flask. Heat the cold mixture to boiling and maintain a moderate boiling for about 15 seconds; lower the flame enough to avoid bumping. Add rapidly further quantities of the sugar solution from the burette until only the faintest perceptible blue color remains. Without removing the flame, add 2 to 5 drops of 1 per cent methylene blue solution; and titrate dropwise until the indicator is completely decolorized. The total volume of the standard solution necessary should be about 24 cc.

To determine the sugar content of the wine, proceed as above, adding 20 cc of the prepared wine solution to 25 cc of the mixed Soxhlet reagent. After boiling it for 15 seconds, finish the titration by adding standard dextrose solution from the burette. If the 20 cc of wine solution completely decolorizes the Soxhlet reagent, dilute the wine solution further, and repeat the determination. For example, take 20 cc, dilute to 100 cc, and take 20 cc of the diluted liquid, multiplying the result by 5.

From the amount of the standard dextrose solution necessary to reduce the copper completely and from the amount necessary to finish the reduction after the addition of the wine solution, the sugar content of the latter can be calculated as follows:

$$\text{per cent of dextrose} = \frac{a-b}{20 \times 0.5},$$

where a is the cubic centimeters of dextrose required for direct titration and b is the cubic centimeters of dextrose required for the back titration.

[188] Fehling's A is made by dissolving 34.639 grams of copper sulfate ($CuSO_4 \cdot 5\ H_2O$) in water and making to 500 cc. Fehling's B is made by dissolving 173 grams of sodium-potassium tartrate (Rochelle salts), and 50 grams of NaOH in water and making to 500 cc.

TANNIN AND COLORING MATTER[189]

The method of analyzing for tannin and coloring matter depends on the determination of the permanganate reducing matter of the wine before and after decolorizing with carbon.

Dealcoholize the wine, cool, and make to the original volume. Transfer 5 cc to an 800-cc beaker. Add about 500 cc of water and exactly 5 cc of indigo solution (made by dissolving 6 grams of indigo—free of indigo blue—in 500 cc of water and 50 cc of H_2SO_4 and making to 1 liter). Titrate with 0.1 N $KMnO_4$ (potassium permanganate) solution, 1 cc at a time, until the blue color changes to green; then add a few drops at a time until the color becomes golden yellow. Thoroughly stir the solution with a glass rod or an electric stirrer during the titration. Designate the cubic centimeters of $KMnO_4$ solution required to reach the golden-yellow color, using the dealcoholized wine, as a.

Decolorize and detannize a portion of the dealcoholized sample by shaking well with carbon. (This charcoal should be free of reducing substances.) Filter and titrate 5 cc, by the same procedure previously used, with $KMnO_4$. Designate the number of cubic centimeters of $KMnO_4$ used for the dealcoholized, decolorized, and detannized sample as b. This volume is fairly constant and for routine work need be determined only in an occasional sample.

Then c, the number of cubic centimeters of $KMnO_4$ solution required for oxidizing the tannin and coloring matter in 5 cc of the wine, may be calculated from $c = a - b$. The amount of tannin as grams per 100 cc of wine is equal to

$$c \times \text{normality of } KMnO_4 \times 0.0416 \times \frac{100}{\text{volume of wine}}.$$

Recently a more specific colorimetric method for determining the tannin content of whiskeys has been proposed.[190] This may also be suitable, after modification, for wine.

ALDEHYDE

The aldehyde content of wine may be determined by the following direct iodometric procedure, although for more accurate results (particularly in highly sulfited wines) the indirect procedure of Jaulmes and Espezel[191] as given in Bulletin 652 for brandy should be used. For free aldehyde distill 100 cc of wine with 50 cc of water into a 300-cc Erlen-

[189] See also p. 20.

[190] Rosenblatt, M., and J. V. Peluso. Determination of tannins by photocolorimeter. Association of Official Agricultural Chemists Journal 24:170–81. 1941.

[191] Jaulmes, P., and P. Espezel. Le dosage de l'acetaldéhyde dans les vins et les spiritueux. Annales des Falsifications et des Fraudes 28:325–35. 1935.

meyer flask placed in an ice bath until about 100 cc of distillate has been obtained. For total aydehydes add 5 cc of 85 per cent phosphoric acid to the wine in the distilling flask before distillation. Joslyn and Comar give the following method for determining the aldehyde content in the distillate:

Mix 100 cc. of the aldehyde solution, 10 cc. of 0.1 *N* sodium bisulfite solution containing 10 per cent of ethyl alcohol by volume, and 10 cc. of alcohol (if the sample contains none) in a 300-cc. Erlenmeyer flask which is stoppered and allowed to stand at room temperature for 30 minutes. (Aldehyde solutions obtained by distillation were cold when bisulfite was added, so that the solutions were not at room temperature during the whole of the storage period.) Then add 10 cc. of 0.1 *N* iodine solution from a freely flowing pipet, and back-titrate the excess of iodine with 0.1 *N* thiosulfate solution. As a blank, to the same volume of water and alcohol add 10 cc. of the bisulfite solution, let stand for 30 minutes, add iodine, and back-titrate as above (1 cc. of 0.1 *N* thiosulfate is equivalent to 0.0022 gram of acetaldehyde).[192]

ESTERS

The esterification of wine has been studied in some detail by Peynaud and others.[193] Peynaud[194] points out that in the usual distillation procedure acetaldehyde introduces an appreciable error in the determination of esters. To reduce this source of error, Espil and Peynaud[195] suggest that an aliquot (50 to 100 cc) of the wine be neutralized with 0.1 *N* NaOH to exactly pH 7 and then extracted in a liquid-liquid continuous extractor with petrol ether, 25 cc of 0.1 *N* NaOH being added to the receiving flask so that saponification and extraction occur continuously. The ester content is determined from the back titration of the alkali remaining. The extraction usually requires 12 hours.

For more quickly determining the ester content, see the procedure for brandies in Bulletin 652.

COLOR

The standardization of color is commonly made by direct visual comparison of the samples. This is satisfactory if an original sample is available, but in most cases it is necessary to specify the color in terms of some permanent physical or chemical standard. The only completely satisfactory method of specifying color is to measure the transmission

[192] Joslyn, M. A., and C. L. Comar. Determination of acetaldehyde in wines. Industrial and Engineering Chemistry, analytical edition **10**:364–66. 1938.

[193] Ribéreau-Gayon, J., and E. Peynaud. Cited in footnote 39, p. 20.

Peynaud, E. Les phénomènes d'estérification dans les vins. Annales des Fermentations 3:242–52. 1937.

Espil, L., L. Genevois, E. Peynaud, and J. Ribéreau-Gayon. Sur la formation des esters de l'alcool éthylique. Enzymologia 4:88–93. 1937.

[194] Peynaud, E. Études sur les phénomenès d'estérification dans les vins. Revue de Viticulture **86**:209–14, 227–30, 248–53, 299–301, 394–95, 420–23, 440–44, 472–73; **87**:49–51, 113–16, 185–87, 242–49, 278–85, 297–301, 344–50, 362–64, 383–85. 1937.

[195] Espil, L., and E. Peynaud. Dosage des esters neutres dans les milieux de fermentation. Société Chimique de France Bul. **3**(série 5):2324–25. 1936.

of light through the wine at various wave lengths of the visible spectrum. This method requires costly equipment and is time-consuming.[196] All the basic color characteristics, however, are specified: dominant wave length, brilliance, and purity. The Dujardin-Salleron vino-colorimeter is useful only for red wines and only young ports may be tested, as the color disks for specifying dominant wave length are not of the same hue as aged ports. For young ports, however, a rough measure of the dominant wave length and the depth of color (brilliance) may be obtained by the use of this instrument. The color dyes recommended by Winkler and Amerine are likewise not well adapted to aged ports unless the proportions are changed to include more brown so that a better color match may be obtained. A fairly permanent color standard for white wines, particularly for sherries, may be made from the Eastman A B C dyes. Ten cc of red and 5 cc each of blue and yellow from 0.5 per cent solutions when made up to 300 cc with water provides a convenient empirical standard.

The use of colored slides of the Lovibond apparatus for specifying color is a further possibility. Both red and white wines may be tested. Although the color data obtained represent arbitrary units, they may be compared with each other and therefore do provide a permanent record of the color characteristics of the wine. They should therefore prove useful in blending tests.

Photoelectric colorimeters or photoelectric spectrophotometers are particularly useful in measuring and recording color in wines. The transmission should be measured with several color filters; the filter showing greatest variation should be used for primary blending.

IRON DETERMINATION[197]

Total iron in wines is most easily and accurately determined by the procedure developed by Saywell and Cunningham.[198] The method involves wet-ashing and the development of a colored complex which ferrous iron forms with o-phenanthroline.

Pipette 2 cc of wine into 25×150 mm Pyrex test tubes previously marked at 10 cc. Evaporate to dryness, cool, and add 1 cc of concentrated H_2SO_4. Heat over a flame under a hood with care until the contents of the

[196] Winkler, A. J., and M. A. Amerine. Color in California wines. I. Methods for measuring color. Food Research 3(4):429–38. 1938.

[197] This section was prepared by George L. Marsh, Associate in the Experiment Station.

[198] Saywell, L. G., and B. B. Cunningham. Determination of iron. Colorimetric o-phenanthroline method. Industrial and Engineering Chemistry, analytical edition 9:67–69. 1937.

See also: Hummel, F. C., and H. H. Willard. Determination of iron in biological materials. The use of o-phenanthroline. Industrial and Engineering Chemistry, analytical edition **10**:13. 1938.

tube are completely liquefied. Allow to cool, and then add 0.5 cc of 70 per cent $HClO_4$ (perchloric acid). Heat *continuously* until partial clarification has occurred, set aside to cool, and then add an additional 0.5 cc of $HClO_4$. Continue the digestion until the sample is clear *and until all the excess $HClO_4$ has been evaporated off.* At this stage set the tubes aside to cool. *Caution:* the digestion should be conducted behind a shatterproof glass, because perchloric acid occasionally explodes during heating.

Add 2 cc of distilled water and a small piece (0.5 cm square) of Congo red paper. Then add 1 cc of a 10 per cent aqueous solution of hydroxylamine hydrochloride and 1 cc of a 0.1 per cent solution of o-phenanthroline in 50 per cent alcohol. Titrate to the color change (blue to a light red) of the Congo red paper with concentrated NH_4OH and set aside to cool. Then make to 10 cc with distilled water and transfer to standardized test tubes for comparison against a series of standards or to colorimeter tubes for comparison by photoelectric photometers.

Prepare a standard stock solution of iron to contain 1 mgm iron per cc.[199] Prepare from this standard stock solution, a series of solutions containing known concentrations (in parts per million of iron). Run these solutions through the procedure given above for the unknown, using all the reagents and following directions closely. Transfer to standard-diameter test tubes and cork tightly for use as a series of standards. These standards are stable for long periods and the procedure outlined automatically corrects for the iron in the reagents. In like manner, the solutions can be used to establish a curve for use with a photoelectric colorimeter. In this case, however, a blank containing water instead of an iron solution but containing all the reagents must be prepared. Use this blank to set the instrument to zero reading.

COPPER DETERMINATION[200]

Quantitative.—Copper in wine is most accurately determined by a modified Coulson[201]-Drabkin[202] procedure. It is a colorimetric test using sodium diethyldithiocarbamate as the reagent for color production. When used under the conditions of the test, the reagent is specific for copper and forms a reasonably stable color complex which can be compared against a series of standards by visual examination or in colorim-

[199] Weigh out 7.022 grams ferrous ammonium sulfate, dissolve in 500 cc of distilled water to which 5 cc of concentrated HCl has been added. Transfer to a 1,000-cc volumetric flask and make to volume with distilled water.

[200] This section was prepared by George L. Marsh, Associate in the Experiment Station.

[201] Coulson, E. J. Report on copper. Association of Official Agricultural Chemists Journal **20**:178–88. 1937.

[202] Drabkin, D. L. Report on copper. Association of Official Agricultural Chemists Journal **22**:320–33. 1939.

eters of the Duboscq type, or against standard curves in photoelectric photometers.

Pipette 25 cc of wine into 100-cc Kjeldahl flasks. Place the flasks in a hot air oven at 100° C and heat until the sample is dry. Remove from the oven and when *cool* add 5 cc of concentrated H_2SO_4 and 5 cc concentrated HNO_3. Heat gently until red NO_2 fumes appear and set aside overnight. Then heat gently at first and more strongly as frothing ceases to the complete disappearance of NO_2 fumes or to the appearance of SO_3 fumes. Set aside to cool and when cool add 1 cc of 70 per cent $HClO_4$. Again heat until the fumes disappear and there is complete clearing of the solution. Cool.

Rapidly add about 5 cc of distilled water and transfer the contents of the Kjeldahl flask to a 150-cc beaker. Wash out the flask and transfer the washings to a beaker, using the minimum amount of water necessary. Add 10 cc of hydrochloric-citric acid reagent.[203] Then neutralize with concentrated NH_4OH to litmus and add 0.2 cc excess. Add 1 cc of a 1 per cent aqueous solution of sodium diethyldithiocarbamate and transfer the contents of the beaker by careful washing to a 125-cc pear-shaped separatory funnel which has been previously marked at 50 cc. Make up to this volume with distilled water. Then accurately pipette 10 cc of isoamyl acetate over the solution, stopper, and shake with reasonable vigor for 1 minute. Allow the two liquid phases to separate, draw off the aqueous phase, dry the stem of the separatory funnel with a pipe cleaner, and then transfer the organic phase of the solution to the colorimetric comparator tubes.

Standard copper solution is best prepared from reagent copper metal (reagent quality) so as to contain 1.25 mg copper per cc. Solution for the preparation of the series of standards is prepared by pipetting 5 cc of the above solution into a 500-cc volumetric flask and making up to volume with distilled water.

Pipette 1, 2, 3, 4, 5, and 6-cc aliquots of the latter solution into 100-cc Kjeldahl flasks. Add 5 cc of concentrated H_2SO_4 and 5 cc of concentrated HNO_3 and boil until all the HNO_3 has been dispelled. Cool, add 1 cc $HClO_4$ and again boil to dispel this latter acid. Again allow to cool and then quickly add 5 cc of distilled water. Transfer the contents of the Kjeldahl flask to 150-cc beakers and proceed as directed above for the unknown. Draw off the extracted colored solution into tubes of the same size and diameter as those used for the unknown and tightly stopper with corks. Compare the unknowns against the standards in a Walpole block or other convenient comparator. Standards prepared as above

[203] For hydrochloric-citric acid reagent, dissolve 75 grams C. P. citric acid in 350 cc of distilled water. Add 50 cc of concentrated HCl, stir, and transfer to a 500-cc volumetric flask and make to volume.

described automatically correct for copper in the reagents and are stable for at least 1 month.

These standards contain 0.0125, 0.025, 0.0375, 0.050, 0.0625, and 0.075 mg of copper per 10 cc of colored solution, which under the conditions of the test corresponds to 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 parts per million of copper in the wine, respectively. If the unknown contains more than 3.0 parts per million of copper, repeat the determination using a smaller aliquot as sample, but make due allowance for the new volume of the aliquot when calculating the copper concentration.

Where a Duboscq colorimeter is available, only two standards at the most need be prepared, one using 1.5 cc of the diluted standard solution, the other using 3.0 cc. At this concentration of copper per cc of colored solution covered by the range of standards above, the color intensity is proportional to the concentration and balancing methods yield reliable values. A photoelectric colorimeter may also be used.

Marsh Procedure.—The Coulson-Drabkin procedure is time-consuming, and careful attention to details is required for accurate results. Nearly as accurate values can be obtained by the following method in a very much shorter period of time and this one is better suited to the average winery laboratory. Wet-ashing is avoided and other innovations are added for purposes of simplification.

Pipette 10 cc of wine into a 25×150-mm Pyrex test tube. Add 1 cc of hydrochloric-citric acid reagent, shake, and then add 2 cc of 5N NH_4OH (333 cc concentrated NH_4OH per liter), and again shake. Then add 1 cc of a 1 per cent aqueous solution of sodium diethyldithiocarbamate, shake and set aside for a minute or so before adding 10 cc of amyl acetate. Follow the addition of amyl acetate with 5 cc of absolute methyl alcohol.

Place the palm of the hand over the top of the test tube and shake vigorously for at least 30 seconds. Set aside and allow the two phases to separate. When separation is complete, draw off the aqueous phase by inserting a length of glass tubing[204] to the bottom of the test tube and apply suction. Then dry the organic phase by adding anhydrous sodium sulfate, powdered, from the tip of a spatula and shaking, adding only a sufficient amount to accomplish the purpose. It should be added while holding the tube at an angle and at the tame time rotating the tube for the purpose of drying the moisture film adhering to the walls. Transfer the dried organic phase to clean dry test tubes for color comparison against a set of standards or to the colorimeter tubes of the Duboscq or any of the new photoelectric colorimeters.

[204] A soda-glass stopcock, drawn to a capillary on one side and connected to a liter filter flask through rubber tubing on the other side, serves the purpose excellently. Connect the filter flask to a water aspirator or vacuum pump.

The absolute methyl alcohol which is added to the reaction mixture serves two purposes. It markedly reduces the tendency of the two phases to emulsify and thereby aids in a quick and clean separation of the aqueous and organic phases. More important, however, is its second purpose. Coulson shows that the intensity of the color which is extractable by amyl acetate from the aqueous phase is dependent upon the pH value of the aqueous phase. At pH 8.0 to 8.5, maximum color intensity is developed and great care must be exercised in adjusting the pH value if accurate values are to be obtained. This is common to most colorimetric procedures and Coulson's method differs little from most others in this respect. It was found in developing the procedure outlined above that when methyl alcohol was added to tubes containing samples adjusted to varying pH values, no difference in color intensity of the extracted colored solution could be detected. Without methyl alcohol, the color intensity of the extracted colored solution was dependent upon the pH value of the aqueous phase. With methyl alcohol present the pH value of the aqueous phase can vary over rather wide limits with no effect on the color intensity.

Standard copper solution for this procedure is best prepared from Merck copper metal (reagent quality) so as to contain 0.50 mg of copper per cc. Solutions for the preparation of the series of standards are prepared by pipetting 1, 2, 3, 4, 5, 6, 8, and 10 cc of the above stock solution into separate 1,000-cc volumetric flasks, adding 150 cc of 95 per cent ethyl alcohol and making each up to volume with distilled water. These solutions then contain 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, and 5.0 parts per million copper, respectively.

Pipette 10 cc of each solution into separate 25 $\times$ 150-mm test tubes and proceed as directed for the unknown. The solutions so obtained can be used as a series of standards or can be used to establish standard curves for use with photoelectric photometers.

SPECIAL TESTS

Heating wines containing levulose causes the formation of hydroxymethylfurfural. This substances gives color reactions with several substances, including rescorcinol. To test for it, shake 10 cc of wine with 10 cc of absolute ether and decant the ether carefully into a small porcelain evaporating dish. Repeat. Evaporate the ether off, and add 2 cc of freshly prepared 1 per cent rescorcinol (in concentrated HCl), and add 5 cc of concentrated HCl. If hydroxymethylfurfural is present, the contents of the evaporation dish turn red. The amount and depth of color is a rough measure of the hydroxymethylfurfural present.

A test can also be made directly in wine with phloroglucinol. In the

case of white wines, the original wine may be used, but red wines must be decolorized with bone charcoal (not with activated charcoal). Place 2 cc of the white or decolorized wine in a test tube, add 1 cc of a freshly prepared 1 per cent phloroglucinol solution (made in 30 per cent HCl) and 2 cc of 30 per cent HCl, and shake. Those wines developing a red or deep-orange color contain hydroxymethylfurfural. A method based on the insolubility of the phloroglucinol precipitate has been developed by Kruisheer and co-workers[205] for the quantitative determination of hydroxymethylfurfural.

The procedure of Kniphorst and Kruisheer (cited in footnote 18, p. 15) may be used to determine 2, 3 butylene glycol.

Glycerin may be determined by the procedure of Bertram and Rutgers,[206] particularly after separation from the sugar by treatment with lime and extraction with alcohol-ether solution, as indicated in the Official Method of the Association of Official Agricultural Chemists.

Sulfur dioxide may be determined by the procedure given in Bulletin 639, page 108.

INTERPRETATION OF RESULTS

Certain analytical determinations in dessert wines are of importance from the standpoint of taxation and should be made with care. Usually the very exact determination of all of the constituents of a wine is unnecessary and time-consuming. Small differences in the amounts of the major constituents of wines have but negligible effects on the quality of the wine. Unless required for taxation purposes as mentioned above, results which can be duplicated within the ranges shown below should be satisfactory.

Substance	Permissible limits of error in determinations
Volatile acid	± 0.006 gram per 100 cc
Total acid	± 0.03 gram per 100 cc
Alcohol	± 0.25 per cent (should be less for procedures other than the ebullioscope)
Extract	± 0.2 per cent
Acetaldehyde	± 1.0 mg per 100 cc
Balling	± 0.2°
Tannin	± 0.01 gram per 100 cc
Esters	± 3.5 mg per 100 cc
Sulfur dioxide, total	± 1.0 mg per 100 cc
Sulfur dioxide, free	± 0.5 mg per 100 cc

[205] Kruisheer, C. I., N. J. N. Vorstman, and L. C. E. Kniphorst. Bestimmung des Oxymethylfurfurols und des Lävulosins in Portwein und anderen Süssweinen. Zeitschrift für Untersuchungen der Lebensmittel 69:570–82. 1935.

[206] Bertram, S. H., and R. Rutgers. The estimation of glycerol and some other hydroxylated compounds. Recueil Travaux Chimiques des Pays-Bas 57:681–87. 1938.

The analyst need only determine if he is using a standard method which will give results comparable with those commonly reported in the literature, and if his duplicate results fall within the ranges suggested. If his results do not agree with those obtained by standard methods or if duplicate analyses fail to agree, he should change his method or technique or equipment.

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